From:	Nan S. Walden
To:	Gaudario, Abigail
Subject:	Article for Administrator
Date:	Tuesday, July 29, 2014 10:40:56 AM
Attachments:	Huckelberry defends negotiating with Rosemont on land preservation.docx

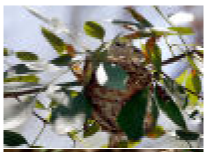
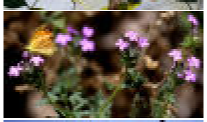
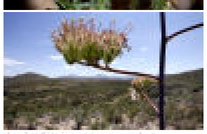
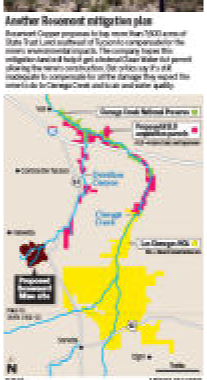
Abigail:

Would you please see that Jared sees this article before we try to talk on Wed at 4pm? I realize our call is tentative and I am flexible Wed and Thursday. Thank you.

Nan

tucson.com
Arizona Daily Star

Huckelberry defends negotiating with Rosemont on land preservation

- 
- 
- 
- 

Kelly Presnell / Arizona Daily Star

Streamside vegetation along Cienega Creek provides homes for several bird species. Bird-watchers, hikers and those interested in archaeological sites are frequent visitors to the riparian area southeast of Tucson.

July 27, 2014 12:00 am • By Tony Davis

15

Pima County Administrator **Chuck Huckelberry** and Rosemont Copper are negotiating a possible deal that could preserve more than 7,600 acres of state trust land in the Cienega Creek and Davidson Canyon watersheds southeast of Tucson.

If the deal goes through — it's too early to tell if it will — it could make it easier for the Rosemont Mine to get a key federal permit allowing construction.

The negotiations have two county supervisors and the head of an anti-Rosemont group upset at Huckelberry, a longtime opponent of the proposed mine.

But making life easier for Rosemont isn't his goal, Huckelberry said. He wants to make sure the county gets the best possible land saved to compensate for other lands the mine would destroy or damage, he said in an interview.

Mitigation — setting aside undeveloped land to compensate for damage done to the mine site and surrounding environs — has eluded Rosemont for years. The deal would also put the mine in line with the county's land-saving guidelines that are typically applied to developers of environmentally sensitive open space.

In general, the land that would be saved lies along portions of Cienega Creek and Davidson Canyon, which are two of Southern Arizona's best-loved watersheds and are classified by the state as "outstanding waters." Huckelberry says he wants to make sure that if the mine is built, mitigation will occur in the same area where many of the mine's impacts will occur: the Cienega Basin, a major watershed connected to the Tucson area's underground aquifer.

FOES OPPOSE TALKS

Opponents of the mine say it's not appropriate for Huckelberry to negotiate with Rosemont over mitigation for the federal permit, although it is OK for him to negotiate over meeting the county's guidelines.

They say his actions could make possible a mine that would have many other damaging impacts besides those covered by the federal permit. That permit would be issued by the Army Corps of Engineers, and cover the mine's federal Clean Water Act requirements. The U.S. Forest Service must also issue a separate approval for the mine.

County Supervisor **Sharon Bronson** said she's "terribly disappointed" and "perplexed" by Huckelberry's negotiations. Fellow Supervisor **Richard Elias** said he's angry at what he called the administrator's shenanigans.

Gayle Hartmann, Save the Scenic Santa Ritas' president, said she doesn't think it's possible to adequately compensate for the mine's impacts no matter where the mitigation occurs. While it's better to have mitigation near the mine, she said she's not sure how relevant that is because the mine will do so much permanent damage to air, water and wildlife habitat.

"We're not at all clear what he thinks he is doing, or why he is doing it. It seems very counterproductive," she said. "What none of that purchasing of property will resolve is that the mine will have disastrous consequences."

Hartmann said Huckelberry would be better off letting the Corps and the EPA proceed with their negotiations with the mining company over the permit. In a sense, Huckelberry is negotiating or trying to negotiate on behalf of the Corps, Elias said.

"I don't necessarily think he should be negotiating on behalf of others. He's providing help for them (Rosemont) to get a permit that they haven't gotten," Elias said. "Chuck's logic is that if the mine is approved, which is likely, then Pima County will be left out of the mitigation thing. I don't think we should be negotiating with anyone until the final decision comes from the Forest Service."

Huckelberry says he's only considering a possible deal with Rosemont Copper to try to ensure that a final Corps permit has the best possible mitigation for its damage to streams and washes near the mine site in the Santa Rita Mountains.

"We would not stop opposing the mine — the first position is that we do not wish to have the mine, period. Our second position is if the mine is approved, the mitigation needs to be in the Cienega Basin," he said.

Without this mitigation plan, the Corps could approve a much weaker one, protecting land outside the Cienega Basin, he said. Even if the Corps' Arizona and regional offices didn't approve such a plan, the national office could overrule them.

So Huckelberry asks and answers a rhetorical question: Is the county an enabler of Rosemont?

"The answer is no. We're not the permitting agency. We don't issue a single permit for Rosemont."

SEPARATE ISSUES

At stake in the negotiations are separate issues. The first involves the county's land conservation guidelines that are applied to most private developers of open land that biologists deem important habitat.

Depending on the quality of the land, a developer is supposed to — but typically is not required to — preserve 66 to 95 percent of the land in a project in return for being able to build there. Until now, Rosemont has not agreed to meet these guidelines.

Second is the Army Corps permit. It would be issued under Section 404 of the federal Clean Water Act, and cover dredging and filling of land in federally regulated washes. Last year, Rosemont offered to buy or otherwise preserve up to 4,500 acres of land and more than 1,700 acre-feet of water rights in Pima and Santa Cruz counties. The Corps, however, has repeatedly found this mitigation plan wanting, although it hasn't denied the permit.

In early May, for instance, the Corps wrote Rosemont Copper CEO **Rod Pace** that it had determined the company's land-saving and water rights purchase plans won't fully compensate for "unavoidable adverse impacts" from the mine. One concern was that Rosemont proposed only "limited" efforts to restore land, which the Corps considers far more important than simply preserving land.
A few weeks later, on June 2, Huckelberry made his first detailed request to Rosemont Copper for specific mitigation lands. In his letter to Pace, however, he was mainly seeking to have the company set aside lands to meet the county's guidelines for preserving open space in new developments.

He requested the company buy about 10,000 acres of state land, in two separate auctions of 5,000 acres each in four places:

- Davidson Canyon, including important riparian areas and adjoining desert lands, considered biological core areas. These lands would maintain a wildlife corridor linking Davidson to the county's Cienega Creek Natural Preserve.
- Lower Cienega Creek, upstream and downstream of Interstate 10. These lands would connect the Cienega preserve to the federal Las Cienegas National Conservation Area, Huckelberry said.
- Santa Ritas linkage areas, to ensure that enough open land exists to allow wildlife to go from Davidson Canyon to the northern end of the Santa Ritas.
- Whetstone Mountain lands, to protect important riparian areas along Wakefield Canyon and maintain wildlife corridors between the Whetstones southeast of Tucson and areas northeast of them. Most of the land lies within designated jaguar critical habitat, and may contain suitable habitat for the endangered ocelot and the Western yellow-billed cuckoo.

On June 20, Rosemont's Pace wrote Huckelberry back, offering to acquire 7,624 acres of state lands in the Cienega Basin. Pace offered to start work on acquiring 5,194 acres immediately and the remaining 2,430 acres within three years after the mine's construction is finished.

Pace proposed to conserve these lands by recording conservation easements or other restrictions on them, by transferring the land to a conservation agency, or by other "appropriate methods." He also offered to buy and dedicate for various conservation and restoration uses nearly 600 acre-feet of water rights, dating back to 1908.

The water would be used to enhance Cienega Creek in and around Pantano Dam in the Cienega Creek Preserve. Now, those water rights are used on a neighboring golf course that diverts water from the creek. Pace also promised to convey to the county 1,200 acre feet of rights to Central Arizona Project water, and provide money to build a pipeline to deliver a backup water supply when necessary.

In return, Pace said he wants the county Board of Supervisors to approve a complex arrangement known as an "In Lieu Fee" project involving Pantano Dam and Cienega Creek. The supervisors would have to approve it as members of the County Regional Flood Control District Board of Directors because the project would be managed by the flood control district.

Typically, an in-lieu program involves restoring, establishing, enhancing or preserving important aquatic resources or lands in which an applicant for a private permit pays a governmental or nongovernmental agency to run the program. It's one form of mitigation commonly OK'd by the Corps in approving Clean Water Act permits.

A year ago, Rosemont Copper proposed to have Pima County and the Tucson Audubon Society manage an in-lieu program involving the water rights for Cienega Creek. Last December, however, Huckelberry abruptly pulled the plug on that program, telling the Army Corps that Cienega Creek doesn't carry enough water most years to meet Rosemont's restoration promises.

Pace’s offer of 1,200 acre feet of CAP water is beyond what Rosemont Copper was offering a year ago, potentially making this deal more attractive to Huckelberry.

Hudbay Minerals Inc., which this month took over Augusta Resource Corp., Rosemont Copper’s parent company, issued a statement Friday saying, “We are studying the impact of these communications and how to best craft final mitigation planning for the Rosemont project.” The statement came from **Patrick Merrin,** Hudbay’s vice president for business development and technical services.

PLAN IS AN “IMPROVEMENT”

Huckelberry said this mitigation plan is “a significant and substantial improvement” over earlier proposals.

He said he’s willing to consider an in-lieu fee program again, but it’s still not enough to mitigate for all real-world impacts of the mine. In part, that’s because many of the mine’s predicted environmental effects are based on computer model studies of which his staff has been critical.

“I want to see what the impacts are going to be in the real world once the mining occurs,” he said. “My concern continues to be, what happens if the predicted model impacts are understated? Who mitigates for that? How does that get mitigated?”

He added that he can’t say how long it will take to work out an acceptable package with Rosemont Copper.

Supervisor Bronson, however, said she’s concerned there’s no assurances today that the state land will be purchased. She also worries that the federal government won’t hold Rosemont’s feet to the fire to make sure the mitigations are performed properly and taxpayers aren’t held responsible if they don’t work.

“Why have the feds been so absent in pursuing these issues?” Bronson asked. “We need assurances that Rosemont will perform should this move forward. If they buy state land, how do we know they won’t sell it?

“Modeling for impacts in the past has always failed. They’re using outdated models. Even saying that modeling is a guess, which is what they have said, we don’t need guesses,” she said. “We need reimbursement for real damage for real occurrences.”

Bronson and Elias say it takes a long time to buy state land and it’s never certain that another buyer won’t outbid a party seeking to buy it for conservation. Supervisor **Ally Miller,** who supports the mine, would not comment on the negotiations. Supervisors **Ramon Valadez** and **Ray Carroll**, both opponents of the mine, couldn’t be reached.

State land purchases are uncertain, because the State Land Department must first agree that selling the lands is in the best interest of the schools and other parties for which it is held in trust. Then, it would conduct appraisals and put the lands up for public auction. The entire sale process takes 12 to 18 months.

Huckelberry said he would assume the mining company couldn’t get its Corps permit until the state land is sold — “I want the mitigation in hand before the mine is permitted.”

Contact Tony Davis at tdavis@tucson.com or 806-7746. Follow Davis on Twitter@tonydavis987

From:	McKaughan, Colleen
To:	jupchurch@fs.fed.us
Cc:	Goforth, Kathleen; Jessop, Carter
Subject:	FW: List of Gaseous Potential HAPs following use of explosives on copper ore
Date:	Monday, July 21, 2014 8:49:55 AM

Mr. Upchurch,

EPA has received this inquiry from a citizen who lives in Green Valley. He is concerned about toxic gaseous emissions from mining explosives, and appears to have participated in both the Forest Service process as well as the ongoing legal process. He wants a response to his inquiry. I am in the process of trying to see what information is available regarding this issue, but to date, I have not been successful in determining whether EPA has identified this issue as a public health concern. The lack of information would indicate that we haven't identified it as such.

Please feel free to call me if you would like to discuss. I understand you are in the field today. I will be in tomorrow, then in Flagstaff and Phoenix for the rest of the week.

Colleen McKaughan
Associate Director
USEPA, Region 9
520-498-0118

-----Original Message-----
From: vfisher@(b) (6) [redacted]
Sent: Friday, July 11, 2014 4:25 PM
To: McKaughan, Colleen
Subject: List of Gaseous Potential HAPs following use of explosives on copper ore

Ms. McKaughan:

Thank you for taking my phone call today about problems of using explosives in open pit mines and generating gaseous HAPs. As I told you,

1. not all HAPs are particulate based or in particulate form.
2. EPA guidance documents do not address problems of gaseous HAPs, except for certain categorical sources. Mines are not a categorical source, but if sufficient HAPs in any form are released in the mine processes that exceed the toxic substance limits for air quality, then regardless source, the source must address the issue and have a Class I permit.
3. I testified about such gaseous HAPs in the administrative hearing appealing the air permit for the Rosemont Mine. None of this testimony was rebutted or countered. It simply was ignored or dismissed on the grounds that ADEQ uses what is available in documents and current documents do not address this issue.
4. I am an appellant now for judicial review of the decision by ADEQ to dismiss my appeal following the adminstrative hearing record release. I filed in Pima County, although ADEQ and Rosemont have requested a change of venue to Maricopa County for their convenience. Unfortunately, my medical situation makes travel very difficult outside of the Tucson area, and I oppose the change of venue.
5. I indicated that I had a list of gaseous HAPs that could potential form following use of explosives on the ore source. I also indicated that during my military service I was did blast studies at a NATO funded US Department of Army research facility, and spectrographic studies following the use of certain explosives showed that some of these compounds did indeed form.

My bad actor HAP list: carbon disulfide, carbonyl sulfide, nickel carbonyl, manganese carbonyl, arsene, phosphene, hydrogen selenide, arsenious acid, methyl lead, methyl mercury. Further, these compounds can attach to aerosols of sulfuric acid and considerable sulfate based aerosols are a product of most explosives.

In addition, thorium, uranium and asbestos are among the particulates available. IARC (International Agency for

Research on Cancer) summarized in Volume 100 of IARC Monographs, that worldwide, all open pit mines release asbestos to the environment. The proposed Rosemont site is on a former depleted uranium claim, therefore TENORM is an issue in the extraction processes for the ore.

This information was presented to the Forest Service also in comments on their Final EIS for the Rosemont Copper Project, and the reviewing officer basically did not consider them. Rather they went with flawed data from Rosemont reports that neither asbestos nor radioactive elements are a problem because they are "de minimus". However, no form of asbestos is de minimus because of its toxicity, the presence of tremolite and erionite (an asbestiform mineral in the landscape) was ignored because a visual examination did not reveal fibrous minerals. Erionite detection often requires x-ray diffraction, which was not used and is a micro analytical method. As for the radioactive elements, the Rosemont background data did not include thorium in any of its analyses, and the reporting of uranium was an after the fact issue raised by the chemical analysis firm, and those data, although included in their overall report, were not included in the compositional analysis of the background mineral sources.

I have attempted to find out who in EPA might address the issue of gaseous HAPs produced following explosions for mining. Unfortunately, I made inquiries during the previous horror periods of sequestering, and most EPA people who could possibly assist were furloughed.

As I told you also, I worked for EPA when it was first created. I was at the Federal Water Pollution Control Administration, later Federal Water Quality Administration, one of EPA's predecssor agencies from 1967 through 1970. Then went on education leave, and then returned to EPA in 1972. I worked there until 1980 where I went to the Department of State. I was one of the original Secretaries of the EPA Science Advisory Board when it was created. During my tenure at Department of State from 1980 through 2006 when I retired, I spent most of my time on Canadian Affairs, so I otherwise coincidentally knowledgeable at certain aspects of British Columbia and Canadian federal policies on air pollution, resource management, and selected industries and companies.

I appreciate any assistance you and your colleagues can provide.

My phone number: (b) (6) [redacted]

email: vfisher@(b) (6) [redacted]

Thank you very much.

Joel Fisher, PhD

From:	Blumenfeld, Jared
To:	Johnson, Kathleen; Horst Greczmiel
Subject:	Fw: Rosemont Mine: HudBay successful in takover of Augusta
Date:	Monday, June 23, 2014 12:16:11 PM

Jared Blumenfeld, EPA

From: Brush, Jason
Sent: Monday, June 23, 2014 12:00:22 PM
To: Blumenfeld, Jared; Diamond, Jane; Woo, Nancy; Evans, David; Kaiser, Russell; Miller, Clay
Cc: Castanon, David J SPL
Subject: Rosemont Mine: HudBay successful in takover of Augusta

From: Jessop, Carter
Sent: Monday, June 23, 2014 11:53 AM
To: Goforth, Kathleen; Johnson, Kathleen; Brush, Jason; Hanf, Lisa; Goldmann, Elizabeth; Leidy, Robert; Diamond, Jane
Cc: Campbell, Rich; PerezSullivan, Margot; McKaughan, Colleen
Subject: Rosemont News - Augusta Resources consents to HudBay takover bid

FYI, Rosemont's parent company, Augusta Resources, has just consented to the takeover bid from HudBay Minerals Inc.

http://www.businessweek.com/news/2014-06-23/hudbay-agrees-to-buy-augusta-for-406-million

HudBay Wins Augusta Takeover Consent With Sweetened Bid

By Simon Casey and Liezel Hill June 23, 2014

HudBay Minerals Inc. (HBM) reached an agreement to buy the rest of Augusta Resource Corp. (AZC) for about C$436 million ($406 million) after sweetening a hostile offer for the developer of the Rosemont copper project in the U.S.

HudBay, which already owns 16 percent of Augusta, will offer 0.17 of a warrant to acquire one of its shares for each Augusta share, in addition to its original offer of 0.315 of a share. The revised bid is valued at about C$3.56 a share, the companies said today in a statement. That's about 10 percent more than the value of HudBay's previous offer based on its closing price on June 20.

The acquisition will allow Toronto-based HudBay to develop Augusta's Rosemont project as its next mine after recently starting up two Canadian operations, with a project in Peru close to completion. The mine, southeast of Tuscon, Arizona, could account for as much as 10 percent of U.S. copper production, according to Augusta.

Augusta jumped 6.3 percent to C$3.40 at 8:50 a.m. in Toronto, before the start of regular trading.

Augusta directors, officers and shareholders that control about 30 percent of Augusta's fully diluted shares have agreed to support the revised offer from HudBay, the companies said today.

The revised offer is accretive to net asset value for HudBay, said Jackie Przybylowski, a Toronto-based analyst at Desjardins Capital Markets.

"We are supportive of the transaction," Przybylowski said in a note today. "The acquisition of Rosemont fills Hudbay's long-term project pipeline and fits well with the company's growth strategy."

Opportunistically Timed

Augusta, based in Vancouver, had rejected HudBay's previous offer as too low and opportunistically timed, saying it expected permits to develop Rosemont would be issued soon and boost its shares. Augusta ran a process to solicit higher bids and said in April it signed agreements to exchange confidential information with 10 groups, but didn't announce any alternate transaction to HudBay's offer.

"After a thorough process to consider all of our alternatives, we are pleased to have agreed on a mutually beneficial transaction representing a successful conclusion to our value maximizing process," Augusta Chairman Richard Warke said in the statement.

HudBay also has a right to match any alternative deal proposed by another party and will receive a fee of C$20 million under certain circumstances if the deal isn't completed.

BMO Capital Markets and GMP Securities L.P. are acting as financial advisers to Hudbay and Goodmans LLP and Milbank, Tweed, Hadley & McCloy LLP are its legal counsel. Augusta is being advised by Scotia Capital Inc. and TD Securities Inc. as financial advisers and Davies Ward Phillips & Vineberg LLP and Cravath, Swaine & Moore LLP as legal counsel.

To contact the reporters on this story: Simon Casey in New York at scasey4@bloomberg.net; Liezel Hill in Toronto at lhill30@bloomberg.net

To contact the editors responsible for this story: Simon Casey at scasey4@bloomberg.net Carlos Caminada

---

blog comments powered by Disqus

Carter W. Jessop
U.S. EPA, Region 9
Environmental Review Section (ENF-4-2)
75 Hawthorne Street
San Francisco, CA 94105
(415) 972-3815
jessop.carter@epa.gov

From:	Goforth, Kathleen
To:	Horst Greczmiel
Subject:	Is there a Rosemont call this Friday?
Date:	Wednesday, January 07, 2015 5:01:00 PM

Hi, Horst –

Happy New Year! I've lost track of the schedule for Rosemont calls. Are we having one this week or is it next week?

Thanks –

-Kathy

From: [Goforth, Kathleen]()
To: [Greczmiel, Horst]()
Cc: [Johnson, Kathleen](); [Jessop, Carter]()
Subject: RE: Canceled: Rosemont Mine Weekly Calls Resuming 16 Jan 2015
Date: Wednesday, January 14, 2015 11:41:13 AM

Horst –

Thanks for your message. Please add Johnson.Kathleen@epa.gov and Jessop.Carter@epa.gov to your email distribution list for the Rosemont calls. In the meantime, I'll let them know that this week's call has been canceled.

-Kathy

-----Original Appointment-----
From: Greczmiel, Horst [[redacted]]
Sent: Wednesday, January 14, 2015 10:31 AM
To: [redacted]

[redacted] CEQ CONSULTATION/REFERRAL [redacted]

From:	Thompson, Elizabeth M -FS on behalf of FS-Video Conference Service Desk
To:	Jessop, Carter
Cc:	mpolm@swca.com
Subject:	RE: VTC setup
Date:	Wednesday, July 09, 2014 3:27:03 PM

Hi Carter,

I have been asked to contact you on behalf of Melissa Polm. She has requested a video conference connection to the EPA for a meeting scheduled on July 23. If you would like to join this video conference, can you please provide the details of how we should connect to you? Will you be using the same equipment that was used for the June 11 call, and should we plan to connect using the same method (SIP) and number?   I have also left a message with Steven Jong to contact us at (b) (6) [redacted]

Thank you,
Bess

Bess Thompson
Video Support
Digital Visions Enterprise Unit

Video Service Desk
(503) 808-2152
Click here to visit the Video Conferencing Service Desk

Click here to open the video bridge reservation form

A Forest Service Enterprise Team http://www.fs.fed.us/digitalvisions

---

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 4:03 PM
To: FS-Video Conference Service Desk
Subject: RE: VTC setup

I assume they will be on the same equipment and I don't have technical contact. If you need to contact them, try Carter Jessup at the email address on my form. Sorry and thanks!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From: Thompson, Elizabeth M -FS [mailto:emthompson02@fs.fed.us] **On Behalf Of** FS-Video Conference Service Desk

Sent: Wednesday, July 09, 2014 12:52 PM
To: Melissa Polm
Subject: RE: VTC setup

Will the EPA be using the same system as for past calls, or do you have a technical contact that we should call to arrange a connection?

Thanks,
Bess

Bess Thompson
Video Support
Digital Visions Enterprise Unit

Video Service Desk
(503) 808-2152
Click here to visit the Video Conferencing Service Desk

Click here to open the video bridge reservation form

A Forest Service Enterprise Team http://www.fs.fed.us/digitalvisions

---

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 1:34 PM
To: FS-Video Conference Service Desk
Subject: RE: VTC setup

7/23/14- I thought I put it on the form- sorry!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From: Bowles, Robert J -FS [mailto:robertbowles@fs.fed.us] **On Behalf Of** FS-Video Conference Service Desk
Sent: Wednesday, July 09, 2014 12:13 PM
To: Melissa Polm
Subject: RE: VTC setup

Hello, I left a voicemail on the phone number provided on the form. Can you please check the date and let us know when the meeting will be held.

Thanks,
Rob

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 12:42 PM
To: FS-Video Conference Service Desk; Bieler, Tracy A -FS; Holley, Teresa J -FS
Cc: Vogel, Mindy S -FS
Subject: VTC setup

All-
My Forest Service email is still getting setup, so I have to use this one, but I need to submit the VTC Bridge form for a meeting in 2 weeks. Please send me back the call in number for people to join via phone, just in case. The location for VTC at NAFRI is tentative, but I will update you once it is confirmed. Also, we have been able to hook in with the EPA VTC equipment at least twice before, so there shouldn't be an issue.

Thanks a bunch!!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

Visit Our Website: http://www.swca.com

From:	Jessop, Carter
To:	FS-Video Conference Service Desk
Cc:	mpolm@swca.com
Subject:	RE: VTC setup
Date:	Monday, July 21, 2014 5:40:00 PM

Hello Bess,

I apologize for the delay in following up with you. We will be using the same equipment as the previous conference, but at a different location and therefore a different SIP. The SIP for the machine we will be using is (b) (6) [redacted] Please let me know if I can provide you any further information to help get this going. This VTC machine is about 100 feet from my cubicle so if there is a need to test it tomorrow, I would be more than happy to do so.

Thanks.

-Carter

Carter W. Jessop
U.S. EPA, Region 9
Environmental Review Section (ENF-4-2)
75 Hawthorne Street
San Francisco, CA 94105
(415) 972-3815
jessop.carter@epa.gov

From: Thompson, Elizabeth M -FS [mailto:emthompson02@fs.fed.us] **On Behalf Of** FS-Video Conference Service Desk
Sent: Wednesday, July 09, 2014 3:26 PM
To: Jessop, Carter
Cc: mpolm@swca.com
Subject: RE: VTC setup

Hi Carter,

I have been asked to contact you on behalf of Melissa Polm. She has requested a video conference connection to the EPA for a meeting scheduled on July 23. If you would like to join this video conference, can you please provide the details of how we should connect to you? Will you be using the same equipment that was used for the June 11 call, and should we plan to connect using the same method (SIP) and number? I have also left a message with Steven Jong to contact us at (b) (6) [redacted]

Thank you,
Bess

Bess Thompson
Video Support
Digital Visions Enterprise Unit

Video Service Desk

(503) 808-2152

[Click here to visit the Video Conferencing Service Desk]

[Click here to open the video bridge reservation form]

Digital Visions
The Technology Professionals

A Forest Service Enterprise Team http://www.fs.fed.us/digitalvisions

---

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 4:03 PM
To: FS-Video Conference Service Desk
Subject: RE: VTC setup

I assume they will be on the same equipment and I don't have technical contact. If you need to contact them, try Carter Jessup at the email address on my form. Sorry and thanks!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From: Thompson, Elizabeth M -FS [mailto:emthompson02@fs.fed.us] **On Behalf Of** FS-Video Conference Service Desk
Sent: Wednesday, July 09, 2014 12:52 PM
To: Melissa Polm
Subject: RE: VTC setup

Will the EPA be using the same system as for past calls, or do you have a technical contact that we should call to arrange a connection?

Thanks,
Bess

Bess Thompson
Video Support
Digital Visions Enterprise Unit

Video Service Desk

(503) 808-2152

[Click here to visit the Video Conferencing Service Desk]

[Click here to open the video bridge reservation form]

A Forest Service Enterprise Team http://www.fs.fed.us/digitalvisions

---

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 1:34 PM
To: FS-Video Conference Service Desk
Subject: RE: VTC setup

7/23/14- I thought I put it on the form- sorry!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From: Bowles, Robert J -FS [mailto:robertbowles@fs.fed.us] **On Behalf Of** FS-Video Conference Service Desk
Sent: Wednesday, July 09, 2014 12:13 PM
To: Melissa Polm
Subject: RE: VTC setup

Hello, I left a voicemail on the phone number provided on the form. Can you please check the date and let us know when the meeting will be held.

Thanks,
Rob

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Wednesday, July 09, 2014 12:42 PM
To: FS-Video Conference Service Desk; Bieler, Tracy A -FS; Holley, Teresa J -FS
Cc: Vogel, Mindy S -FS
Subject: VTC setup

All-
My Forest Service email is still getting setup, so I have to use this one, but I need to submit the VTC Bridge form for a meeting in 2 weeks. Please send me back the call in number for people to join via phone, just in case. The location for VTC at NAFRI is tentative, but I will update you once it is confirmed. Also, we have been able to hook in with the EPA VTC equipment at least twice before, so there shouldn't be an issue.

Thanks a bunch!!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From:	Deborah Haro
To:	"scalamera.robert@azdeq.gov"
Cc:	"Marjorie.E.Blaine@usace.army.mil"; Blumenfeld, Jared; Ally Miller; Andres Cano; Andres Vargas; Anissa Ramirez; Benny Gomez; Evangelina Quihuis; Frank Franco; Jeannie Davis; Jennifer Cabrera; Jennifer Eckstrom; Jennifer Wong; Joseph Cuffari; Keith Bagwell; Kiki Navarro; Marcos Perez; Michael Lundin; Paula Maxwell; Ramon Valadez; Ray Carroll; Richard Elias; Rosie Alexander; Sharon Bronson; Shirley Lamonna; Tom Ward
Subject:	Rosemont ADEQ 401 Certification
Date:	Wednesday, July 16, 2014 4:48:44 PM
Attachments:	rs-rosemont adeq 401 certification.pdf

Hello Mr. Scalamera,

Please see the attached correspondence from Mr. Huckelberry regarding Rosemont. The original letter will be provided to you via US mail.

Thank you,
Debbie

Deborah Haro
520-724-8770
520-770-4201 Right Fax
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
Pima County Administrator's Office
130 W. Congress Street, Floor 10
Tucson, Arizona 85701
Deborah.Haro@pima.gov

COUNTY ADMINISTRATOR'S OFFICE

PIMA COUNTY GOVERNMENTAL CENTER
130 W. CONGRESS, FLOOR 10, TUCSON, AZ 85701-1317
(520) 724-8661 FAX (520) 724-8171

C.H. HUCKELBERRY
County Administrator

July 16, 2014

Robert Scalamera, Project Manager
Arizona Department of Environmental Quality
Surface Water Section, MC5415A-1
1110 W. Washington Street
Phoenix, Arizona 85007

Re: **Arizona Department of Environmental Quality 401 Certification for Rosemont Copper, Public Notice 27-14AZ LTF 55425**

Dear Mr. Scalamera:

Pima County Regional Flood Control District and Pima County provide herein additional information for your consideration that is relevant to the proposed 401 certification for the Clean Water Act Section 404 permit for the Rosemont Copper Project, Public Notice/ Application No: SPL-2008-00816-MB.

Our previous comments to you took issue with some of the key assumptions that underlie the Final Environmental Impact Statement's (FEIS's) conclusions regarding effects to Davidson Canyon. These comments included a new interpretation of Rosemont's isotopic data by Dr. Chris Eastoe that differs from conclusions provided by Rosemont's consultants. Since then, we have identified additional technical flaws in the information provided by Rosemont's consultants, TetraTech and WestLand Resources, for the FEIS that we would like to bring to your attention via the attached report.

As you may know, the federal agencies convened a hydrology group meeting on June 10 and 11, 2014 to identify new data sources and analyses for impact analysis. In response, we identified additional observations and data from the Pima Association of Governments and Pima County. The resulting report, *Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of the Cienega Creek Natural Preserve,* provides the best available dataset for understanding the relationship between groundwater levels, surface water availability, and habitat for federally listed wildlife. The key results of our analyses are that:

1. There is an important and highly statistically significant link between surface water flow extent and groundwater resources in Lower Cienega Creek and Davidson Canyon. The correlations found in our new analyses are so significant, in fact, that their possibility of occurring by chance is nearly impossible.
2. Analyses by WestLand, TetraTech and SWCA for the FEIS have consistently underestimated the length of streamflow in Cienega Creek and Davidson Canyon that will be impacted by the mine.
3. The net result will be a loss of habitat and take of endangered species that exceeds previous considerations.

Please advise me as to whether the Arizona Department of Environmental Quality will consider the attached information in the 401 certification for this project.

Sincerely,

C. Huckelberry

C.H. Huckelberry
County Administrator

CHH/mjk

Attachment

c: The Honorable Chair and Members, Pima County Board of Supervisors
Marjorie Blaine, Senior Project Manager, US Army Corps of Engineers
Jared Blumenfeld, Region IX Administrator, US Environmental Protection Agency

Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of the Cienega Creek Natural Preserve

Brian Powell[1], Lynn Orchard[2], Julia Fonseca[1], and Frank Postillion[2]

July 14, 2014

[1]Pima County Office of Sustainability and Conservation

[2] Pima County Regional Flood Control District

Suggested Citation

Powell, B., L. Orchard, J. Fonseca, and F. Postillion. 2014. Impacts of the Rosemont Mine on hydrology and threatened and endangered species of the Cienega Creek Natural Preserve. Pima County, Arizona

Cover Photo: End of flow for one section of Cienega Creek at the Cienega Creek Natural Preserve. May 2014.

Introduction

If constructed, the Rosemont mine will reduce streamflow and groundwater inputs into Cienega Creek and Davidson Canyon. The uncertainty and discussions have been about the magnitude of that impact and how much, if any, projected changes will compromise populations of threatened and endangered (T&E) species and their habitats (e.g., Tetra Tech 2010a, b, WestLand Resources Inc. 2011, Pima County 2012, SWCA Enivironmental Consultants 2012, Pima County 2013). This is a critical question; lower Cienega Creek (herein, Cienega Creek unless otherwise noted) in the Cienega Creek Natural Preserve (CCNP) and in Davidson Canyon[1] provide both a critical water supply to the Tucson Basin and are a refugia for aquatic and riparian plants and animals found in few other places in Pima County.

This report provides the most comprehensive evaluation of the extensive water resource data that has been collected at CCNP as it relates to potential impacts from the Rosemont mine. We focus first on developing robust predictive models, apply those models to estimate a range of impacts to baseflow and length of streamflow, question some past analyses and assumptions about the lack of connection between surfacewater and groundwater, highlight key uncertainties that inhibit our ability to understand the full breadth of impacts from the mine, and finally, we combine the water resources data with our best understanding of the distribution of habitat for the aquatic and riparian T&E species that currently occur or recently occurred at the CCNP to estimate loss of habitat as a result of the mine.

<u>A Note About Models and Their Use</u>. Previously, estimated effects of the proposed mine on streamflow—particularly in reaches of perennial or intermittent flow—have been addressed primarily through groundwater modeling (e.g., Montgomery and Associates Inc. 2010, Tetra Tech 2010b, SWCA Enivironmental Consultants 2012). These models have then been used to estimate impacts on species in Cienega Creek and its major tributaries (U. S. Fish and Wildlife Service 2013). The final environmental impact statement (FEIS; U.S. Forest Service 2013) for the Rosemont project states that predicting sub-foot scale drawdowns at great distance and time scales is "beyond the ability of these groundwater models, or any groundwater model, to accurately predict." Nevertheless, sub-foot model results were presented as a basis to determine mine impacts on Outstanding Arizona Waters in Davidson Canyon and Cienega Creek (WestLand Resources Inc. 2011, 2012) and to draw conclusions about effects on T&E species. In this report, we also use subfoot groundwater model results as the best available information, but draw different conclusions than those of WestLand (2011, 2012).

[1] In this report, data collected in Davidson Canyon refer to areas in the CCNP and/or in Pima County's Bar-V Ranch.

In striving to understand the potential impacts of water loss on these critical riparian areas and the T&E species they support, it is prudent to investigate a range of potential impacts in areas where the existing analysis is inadequate to provide the level of detail needed to understand the Rosemont projects' effects on the downstream environment. Analysis provided in this paper endeavors to aid in "informing the decision" by presenting a range of potential impacts based on empirical data systematically collected from wells and field excursions over several years (e.g., Pima Association of Governments 2009a, 2011). This analysis of well depth vs. baseflow and length of streamflow and other analyses in Cienega Creek and Davidson Canyon acknowledges the limitations of the groundwater models and presents a range of groundwater drawdown effects that are reasonable to consider given the uncertainties of groundwater models and natural variation experienced during the monitoring period at the CCNP.

Methods

Field Methods. To determine the loss of surface water, we first developed models using data from the depth of water in wells and baseflow and total length of streamflow at two sites: (1) Cienega Creek and (2) Davidson Canyon. Much of the data collection methods and location maps are summarized in Powell (2013). For this effort we used data collected as recently as 2014 (Cienega Creek) and 2013 (Davidson Canyon), the most up-to-date information that we could receive from the Pima Association of Governments, which collects the data. June data were used to determine the relationship between depth to groundwater and streamflow length from 2000-2014 for Cienega Creek, but for Davidson Canyon, all data were aggregated to model this relationship, in part because of the smaller sample size (sample collections were started in late 2005 at Davidson). June samples were selected for Cienega Creek for a number of reasons such as length of record and because streamflow length data represents a critical low-flow for the system. Depth to water was measured at the Cienega Well (Cienega Creek) and Davidson #2 Well (Davidson Canyon[2]). Depth to water in wells and mapping of streamflow length were always measured on the same day. We also developed models for the relationship between streamflow volume (cubic feet/second; herein referred to as baseflow), which is measured quarterly at the Marsh Station Bridge (again, see Powell 2013 for the more information) and depth to water at the Cienega Well. We used all quarterly sampling data from June 2001 to June 2014 for this analysis.

Data Analysis

[2] The Davidson #2 Well and streamflow reach are located in "Reach 2", as defined by Tetra Tech.

Relationship between streamflow, depth to groundwater, and baseflow. We used linear regression to model the relationship between depth to water (in feet) and streamflow length (in miles) and baseflow (ft^3/sec). To model these changes, we interpolated the regression model to predict what changes in the response variables (i.e., baseflow and streamflow length) would result from a lowering of the water table by 0.1, 0.2, and 0.25 feet. This represents a look at the potential impacts to baseflow and streamflow length if the modeled results in Montgomery and Associates Inc. (2010) and Tetra Tech (2010b) occur as predicted (0-0.1 feet drawdown at Cienega Well, 0.10-0.98 feet at Davidson Well[3] for streamflow length). At Cienega Creek we looked at scenarios where drawdown will be slightly greater than predicted by the models to describe potential impacts if model results are not accurate (e.g., 0.2 - 0.25 feet drawdown at Cienega Well). For baseflow estimates we calculated total annual acre feet of baseflow lost, as well as seasonal estimates. Because baseflow was measured four times per year, we assumed these flow estimates represented seasonal averages. We used the annual and seasonal average baseflow to estimate the percentage of baseflow that would be reduced from groundwater drawdown. We log-transformed flow volume data to fit assumptions of the normal distribution for the regression analysis.

Fragmentation of Flow. One of the concerns about the loss of streamflow length is that the stream may also become more fragmented, which might isolate populations of fish, in particular. Fish caught in small, fragmented reaches would be more susceptible to extirpation due to a variety of factors, including predation and of course, loss of habitat. To model this for Cienega Creek, we first calculated the number and length of individual stream reaches (derived from individual start and stop points collected in the field). We then calculate intra-annual summaries, including the coefficient of variation in stream length[4] and total number of flow length segments over time. Finally, we used the results of the modeled changes in streamflow length as a function of depth to water in wells to understand how this might further fragment the system. Based on the modeled results for a drawdown of 0.25 feet, we calculated the number of streamflow lengths measured from 2001-2012 (the most complete set of information for which four seasonal measurements are each year) that were equal to or less than the predicted loss in streamflow length (1,085 feet), which we call the *threshold length*.

---

[3] Davidson Well #2 is located approximately 1.8 miles north of the Montgomery and Associates 5-foot drawdown contour (in Montgomery and Associates Inc. 2010). That modeling effort showed a 0.31 foot drawdown at 150 years in Reach 2, and 0.98 feet at 1,000 years.

[4] Coefficient of variation (CV) is the standard deviation divided by the mean. For this study, CV provides a good method of comparison among years, because the mean flow length has changed considerably over time. Therefore, comparing standard deviations is not as informative.

We then developed a multiple regression model to determine the relationship between the number of flow segments that met or exceeded this threshold and other factors thought to influence flow segments including length of flow, year, month, and month*year interaction[5].

Testing accuracy of groundwater-surface water relationship. We used 2008 and 2011 LiDAR to evaluate the accuracy of the groundwater-surface water relationship at the Davidson Well #2 and compared these data to figures and language in Tetra Tech (2010a) to determine if the Tetra Tech analysis was correct. A review of the LiDAR data collection can be found in Swetnam and Powell (2010).

Results and Discussion

Cienega Creek: Baseflow. From 2001-2014 average annual baseflow was 0.73 ft^3/sec but this varied considerably by month: March = 1.12 ft^3/sec, June = 0.32 ft^3/sec, September = 0.91 ft^3/sec, and December = 0.65 ft^3/sec. Baseflow declined as depth to groundwater increased, as explained by a linear function ($F_{1,56}$= 157.2, $P < 0.001$, $R^2 = 0.74$) (Figure 1). All four sampling

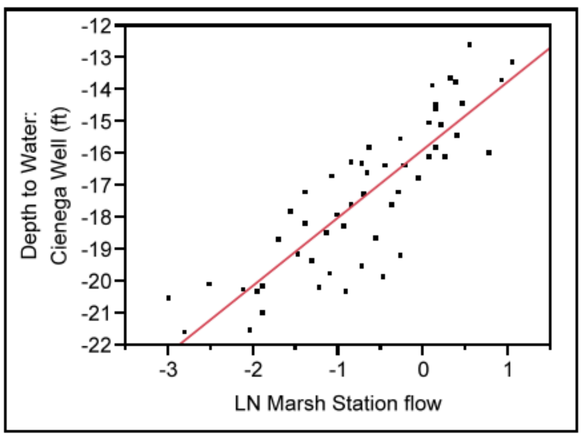


Figure 1. Relationship between flow (log [LN] of cubic feet/second) and depth to water at the Cienega Well. The linear model (red line) explains 74% of the variation in the data. Model used all data from June 2001-June 20014.

[5] In regression analysis (and for this situation), *interaction* occurs when a relation between two variables is modified by another variable. In other words, the strength or the sign (i.e., direction) of a relation between two variables is different depending on the value of some other variable.

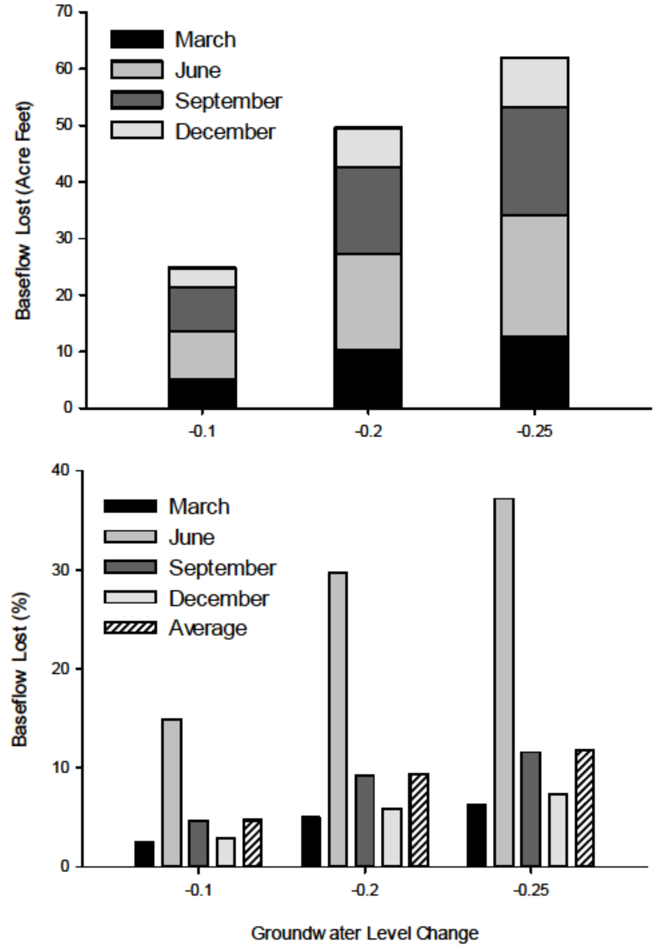


Figure 2. Modeled loss of streamflow volume (acre feet [top] and percent [bottom]) as a function of changes in groundwater level, by season. While total flow loss for the June period is similar to that of September, for example (top graph), this greater percentage of baseflow lost results from the lower baseflow volume during June.

periods (March, June, September, and December) showed a similar relationship ($P<0.004$), with the strength of the model fit (as expressed by R^2) ranging from 0.54 for December to 0.81 for March. Using the regression equations, we were able to calculate that with a 0.1 feet decline in groundwater elevation would lead to an average annual loss of 25 acre feet of water (Figure 2). Annual losses increase to 63 acre feet with 0.25 feet reduction in groundwater level at the Cienega Well.

Perhaps more important than total volume of water lost is the percentage of baseflow predicted to be lost. Average annual estimates of baseflow reduction range from 4.7% with a 0.1 feet reduction of groundwater level to 11.8% reduction with a 0.25 feet reduction (Figure 2)

As reported earlier, baseflow varied among months and this made inter-month percent loss in baseflow quite different than total loss. June is especially important to notice; it showed an estimated 14.9% loss of baseflow at Marsh Station with a 0.1 feet decline in the aquifer to as high as 37% with a 0.25 feet decline in the aquifer (Figure 2).

Cienega Creek: Streamflow length. Streamflow length and depth to water was explained by a linear function ($F_{1,12}$= 67.2, $P < 0.001$, $R^2 = 0.84$)[6] (Figure 3). Using this model, we would expect that a groundwater drawdown of 0.1 foot would result in a loss of 434 linear feet of Cienega Creek (Table 1). Because of uncertainty about the models and the high value of Cienega Creek, we also modeled drawdown of 0.25 feet, which results in a reduction of streamflow length of 1,085 feet. The mean extent of streamflow within the CCNP from 2000-2013 has been approximately 12,500 feet. A reduction of 434 feet would reduce surface water extent by 3.4% and 1,085 feet would be equal to approximately 8.6% reduction is flow extent.

It is important to note that the Cienega Well was used in the report by Westland (2012; page 5), but they claim that their model of depth to water and quarterly flow length showed an unusual statistical distribution and therefore use of that well was discounted in favor of data from the Jungle well. The June length of flow data in relation to the Cienega Well do not show this issue (Figure 4) and the Cienega Well is certainly useful for estimating loss of streamflow length.

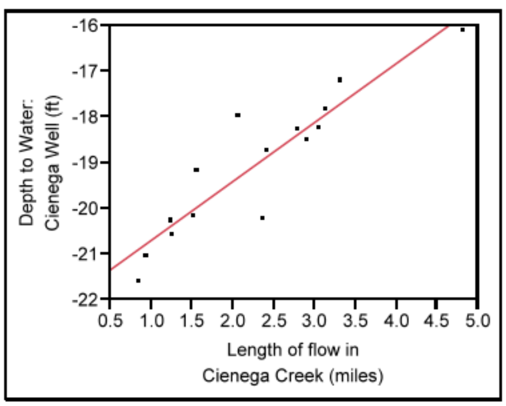


Figure 3. Relationship between length of flow of Cienega Creek at the Cienega Creek Natural Preserve and depth to water at the Cienega Well. The linear model (red line) explains 84% of the variation in the data.

---

[6] It is important to note that we also modeled the relationship using a 2nd and 3rd order polynomial, which improved results somewhat, particularly for the 3rd order polynomial (R^2 = 0.87). However, for simplicity, we use the following formula to model the impact in groundwater drawdown on Cienega Creek within the CCNP: Length of flow (miles) = 14.662 + 0.650*depth of water at the Cienega Well (feet).

Table 1. Modeled reduction in streamflow length of Cienega Creek at the Cienega Creek Natural Preserve. Percent reduction is based on the mean June streamflow length of 2.38 miles (12,566 feet).

Draw-down (feet)	Arbitrary starting well depth (feet)	Streamflow length		Feet lost due to draw-down	Percent reduction in streamflow length
		Miles	Feet		
0	-18	3.10	16,347	0	0.0
-0.1	-18.1	3.01	15,913	-434	-3.4
-0.2	-18.2	2.93	15,479	-868	-6.9
-0.25	-18.25	2.90	15,262	-1085	-8.6

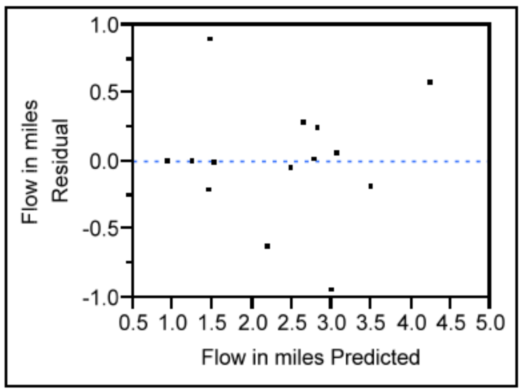


Figure 4. The dispersion of residuals from the model of streamflow length in Cienega Creek to depth to water in Cienega Well (June; Figure 1) shows that a linear model for this relationship is a valid statistical approach. Westland (2012), using data from all intra-annual streamflow lengths measurements, argued that this was not a statistically valid relationship. (Myers [2014] had similar issues with data from Empire Gulch). However, by using June data only, a linear model is appropriate.

It is critical to note that the results between the modeling results by Westland (2012) and those reported here are significantly different. Using data from the Jungle Well, Westland (2012) found that with a 0.1 foot decline in depth to water there would be 176 foot reduction in flow length; just 41% of our results. They also did not model a scenario that may result from a mine impact that is greater than other projections but may be within the realm of possibility (i.e., a 0.25 foot reduction in depth to water).

<u>Davidson Canyon: Groundwater and Baseflow Extent</u>. Streamflow length and depth to water was explained by a linear function ($F_{1,26}$= 89.9, $P < 0.001$, $R^2 = 0.78$) (Figure 5), which we used to model the impact in groundwater drawdown on Davidson Canyon: Length of flow (miles) = 2.180 + 0.085*depth of water at the Davidson #2 Well (feet) (Figure 5).

Using this model, we would expect that a groundwater drawdown of 0.1 foot would result in a loss of 45 linear feet of Davidson Canyon and a drawdown of 0.25 feet resulted in a reduction of streamflow length of streamflow of over 112 feet (Table 2). Percent reductions are very similar to that of Cienega Creek and ranged from 3.0% to 7.6%. Using the 150 and 1,000 year estimates of impacts on groundwater (0.31 feet and 0.98 feet, respectively; Montgomery and Associates, 2010) would result in 9.4% and 30% loss of surface flow in Davidson Canyon, respectively. For comparison, the groundwater model by Montgomery and Associates (2010) equates the 0.98 feet of drawdown with a 0.29 miles (1,530 feet) reduction in stream length based on the drying of several of the 800 x 800 foot model grid cells where leakage to the aquifer exceeds streamflow into the reach.

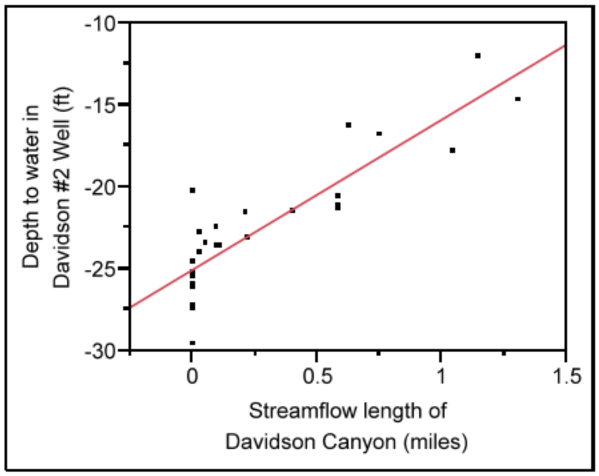


Figure 5. Relationship between length of flow of Davidson Canyon at the Cienega Creek Natural Preserve and depth to water at the Davidson #2 Well. The linear model (red line) explains 77% of the variation in the data. This model does not take into consideration changes in surface water runoff from the mine site.

Table 2. Modeled reduction in streamflow length for Davidson Canyon. Percent reduction is based on the mean June streamflow length of 0.28 miles (1,478 feet).

Draw-down	Arbitrary starting well depth in feet	Streamflow length: Miles	Streamflow length: Feet	Feet of streamflow lost due to draw-down	Percent reduction in streamflow length
0	-20	0.4885	2,579	0	0.0
-0.1	-20.1	0.4800	2,534	-45	-3.0
-0.2	-20.2	0.4716	2,490	-89	-6.0
-0.25	-20.25	0.4673	2,467	-112	-7.6
-0.31	-20.31	0.4622	2,441	-138	-9.4
-0.98	-20.98	0.4071	2,141	-438	-30.0

Unlike in Cienega Creek, the groundwater model results used here to calculate drawdown are taken from locations within or very near the 5-foot drawdown contour and are assumed to be more reasonably certain than model results for Lower Cienega Creek. Accordingly, the stream length losses associated with nearly a foot of drawdown must be taken into consideration when evaluating the Rosemont mine's impact on lower Davidson Canyon. The stream length losses (0.29 miles; 1,530 feet) predicted by Montgomery and Associates (2010) are larger than those predicted in this study using the well depth to stream length regression analysis (Table 2). Taken together however, they provide a range of possible outcomes resulting from increased depths to groundwater due to the Rosemont mine.

Tetra Tech (2010a) suggests that this reach of Davidson Canyon is not connected to the regional groundwater system, and that streamflow impacts due to drawdown of the regional aquifer therefore are unlikely to occur. Yet the results of our analysis (Figure 5) provide very convincing evidence that contradicts this position.

We also take issue with Tetra Tech (2010a) data. Underpinning Tetra Tech's assertion is an illustration and a channel bed measurement at the Davidson Canyon stream gage (Figure 6). The accuracy of this figure relies on a "mid-channel bed" measurement taken by Tetra Tech (2010a). We examined Pima County LiDAR-generated elevation data at the same location and found that Tetra Tech's "mid-channel" bed elevation is five feet higher than the channel bed in 2008. We then examined 2011 LiDAR bed-elevations at the same location, which rule out the possibility that five feet of aggradation occurred, as would be required by Tetra Tech channel bed measurement. Instead, the actual bed elevations in 2008 and 2011 vary by less than 0.6 feet (Figure 7). Thus, the actual channel-bed is within a foot or two of the water table as measured in Davidson #2 Well.

The water-level measurements presented by Tetra Tech came from the Outstanding Waters nomination submitted by Pima Association of Governments (2005), which identified this reach as intermittent. Tetra Tech (2010a) uses the same data to infer than this portion of the channel is ephemeral. It is unreasonable to assume that groundwater never could discharge to the surface, or that it has been persistently below the bed between 1994 and 2004, as is indicated by Tetra Tech with the horizontal line connecting the last two groundwater measurements (Figure 6). It is even more unreasonable to extend that inference to the entire upstream reach, as is done by Tetra Tech (2010a).

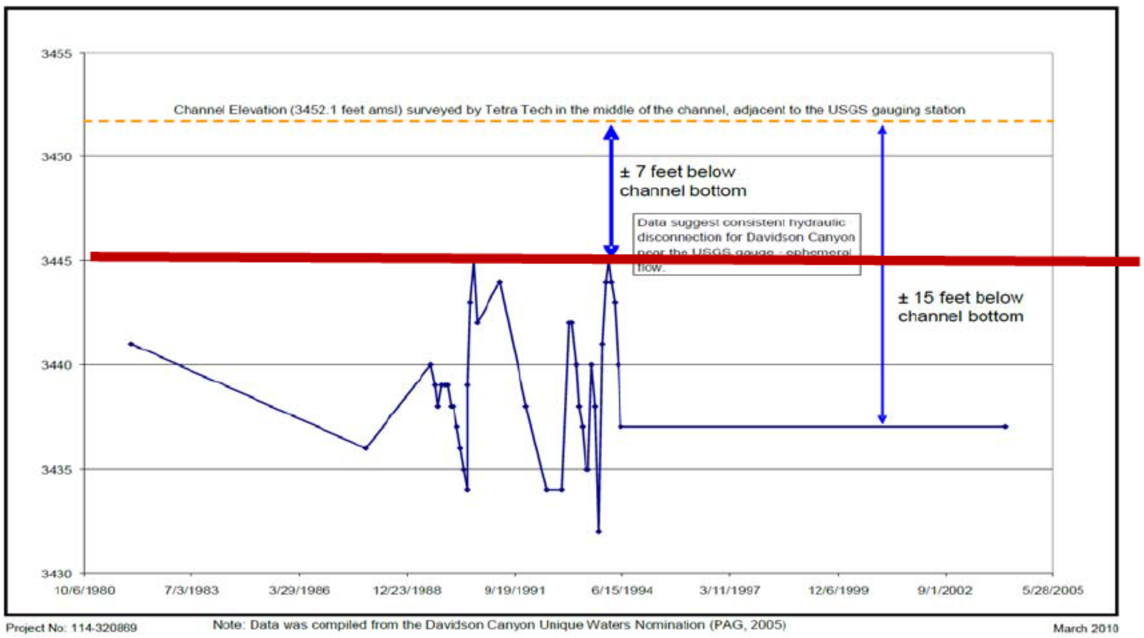


Figure 6. Tetra Tech's (2010a) Figure 5, amended to show actual channel bed elevation at the location. Red line shows position of the 2008 and 2011 channel bed based on LiDAR data.

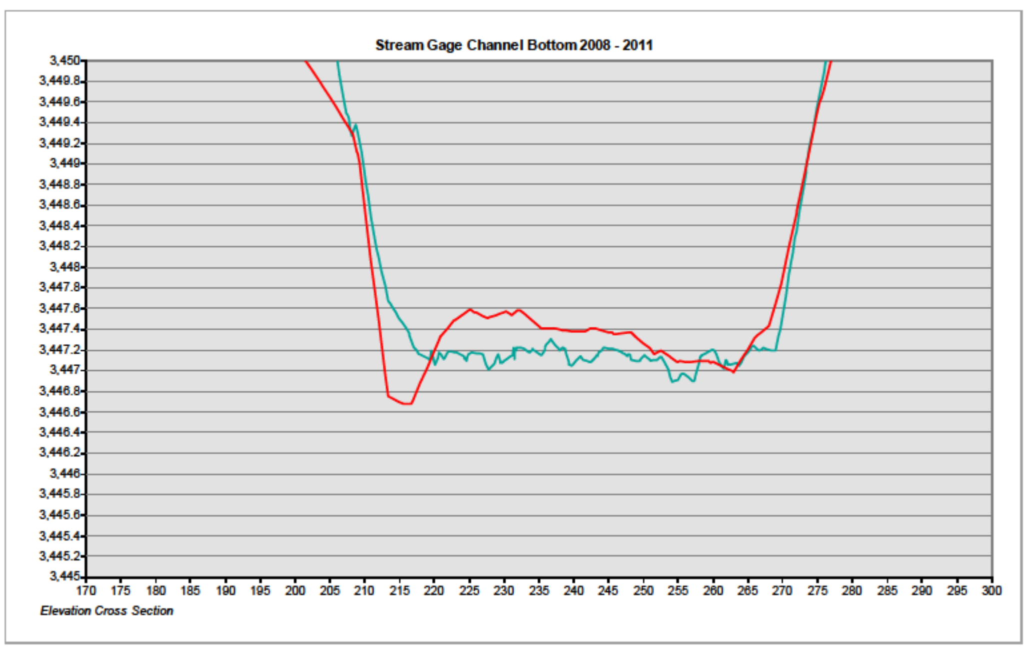


Figure 7. LiDAR channel cross-sections, 2008 in red, 2011 in green. Bed elevation varies by less than 0.6 feet.

Additionally, the work of Montgomery and Associates (2010) supports a connection to the regional aquifer in lower Davidson Canyon. The pre-mining steady state model simulated the interaction between the regional aquifer and the stream. The model produced results for both discharge and streamflow length that approximately matches past observations of flows and the extent of the Davidson perennial reach. If the regional aquifer was disconnected from the perennial reach, or so far below it that it does not impact surface flows, then one would expect that to be reflected in the model simulation showing a dry reach. It does not. Further evidence supporting a connection to the regional aquifer comes from interpretation of isotopic data by Dr. Chris Eastoe (Letter from County Administrator's Office to Robert Scalamera, Project Manager, Arizona Department of Environmental Quality (ADEQ); letter dated April 4, 2014).

These various lines of evidence, combined with errors and omissions by Tetra Tech, undermines Tetra Tech's argument that the intermittent baseflows in Davidson are unrelated to the regional aquifer. Combined, these analyses suggest that the impacts of Rosemont mine on Davidson Canyon and the Outstanding Arizona Waters have been understated in both the final environmental impact statement (U.S. Forest Service 2013), the draft water quality certification by ADEQ (Arizona Department of Environmental Quality 2014), and the biological opinion (U. S. Fish and Wildlife Service 2013). Based on this new information, the impact to the Davidson Canyon Outstanding Arizona Waters reach by the Rosemont project should be revaluated regarding the potential take of endangered species and the impact to riparian and water resources.

<u>Davidson Canyon: Effect on Runoff</u>. Key to understanding the mine's full impact on water resources requires a better understanding of the surface water runoff changes in the Barrel and Davidson canyons. Pima County has repeatedly objected to the methodology and the findings from Rosemont and their consultants as well as data that have been incorporated into the final environmental impact statement and biological opinion including that:

- Potential runoff reduction impacts on downstream riparian and water resources for all phases of the mine life are not fully disclosed.
- Cumulative runoff reduction impacts on downstream riparian and water resources, Davidson Canyon and Cienega Creek, are not fully disclosed.
- Deficiencies in the analysis of downstream water volume effects on Davidson Canyon, Cienega Creek and Outstanding Arizona Waters have resulted in the underestimation of reduction in surface water flows in FEIS.
- The hydrological analysis supporting the surface water evaluation is inadequate, as the modeling should have considered shorter duration, high-intensity rainfall events' and the FEIS misrepresents the methods followed as those prescribed by Pima County.
- Rosemont Copper still intends to capture and retain surface water from watersheds northeast of the tailings, west of the mine pit, and south of the waste rock disposal

area. Instead, this water should be released downstream to mitigate reductions in stream flows and impacts to riparian vegetation.

To inform the decision regarding the impact to riparian resources and potential take of endangered species, these runoff-related objections need to be addressed. In addition to the above mentioned objections, the Biological Opinion cites work by SWCA (2012) that has not been made available for Pima County's review, either as a Cooperator or as a participant in the Hydrology Work Group recently convened by the Federal agencies. The SWCA work apparently extrapolates runoff volume reductions in Barrel Canyon and Davidson Canyon above the Highway 83 bridge to the Outstanding Arizona Water reach downstream.

Acceptable methods for determining flood routing are described in Pima County Regional Flood Control District Technical Policy 18. In this document, the methods entitled "*Acceptable Model Parameterization for Determining Peak Discharges"* should be employed to determine the reduction in streamflow in Lower Davidson Canyon and Cienega Creek as a result of changes in the upper watershed due to the Rosemont project. Myers (2014) provides an additional critique of Westland's (2012) methodology to evaluate impacts of surface water impoundments on Davidson Canyon and highlights that the methods used are deficient to provide an understanding of the impacts.

Rosemont and their consultants have reported that reductions in the volume of channel infiltration in the headwaters, reductions in total annual runoff volume, and reductions in peak flood magnitude all will have minimal effects on the OAW reach (WestLand Resources Inc. 2011, Zeller 2011, SWCA Enivironmental Consultants 2012). Combined with previously discussed Tetra Tech (2012a, 2012b) interpretations, these arguments would suggest that:

- When groundwater is considered, surface water is the most important factor in supporting lower Davidson Canyon.
- When mine impacts that effect surface water are considered, lower Davidson is too distant from the headwaters to be impacted.
- When shallow groundwater and channel subflow from precipitation recharge in the headwaters are considered, the OAW reach is not connected to the upper watershed due to bedrock constrictions in the shallow aquifer.

These arguments, when summed up, suggest that the OAW reach of Davidson Canyon is isolated from its watershed entirely and apparently without a water source. In short, these studies reveal a disturbing pattern of minimizing impacts from the Rosemont mine on all aspects of the hydrologic cycle.

Fragmentation of Flow in Cienega Creek. As has been reported elsewhere (WestLand Resources Inc. 2012, Powell 2013), streamflow length of Cienega Creek has declined precipitously since the 1980's and 1990's (Figure 8). In part because of this decline, streamflow length became highly variable as the streamflow responded to a shallow aquifer that was declining because drought and groundwater pumping. Looking more closely at the streamflow length data, not only was the streamflow length declining, but the streamflow segments were becoming more fragmented. This variability can be seen a number of ways, including the coefficient of variation (Figure 9) and number of segments per year (Figure 10).

From June 2001 to September 2012, there were a total of 341 recorded stream segments, 161 of which (47%) were at or below the threshold length established for this analysis (i.e., 1,085 feet). The number of stream segments below the threshold length was most influenced by length of flow in Cienega Creek (multiple regression, $F_{4,40} = 5.4$, $P = 0.0015$, $R^2 = 0.35$; Table 3) and not by any other factor (Table 3).

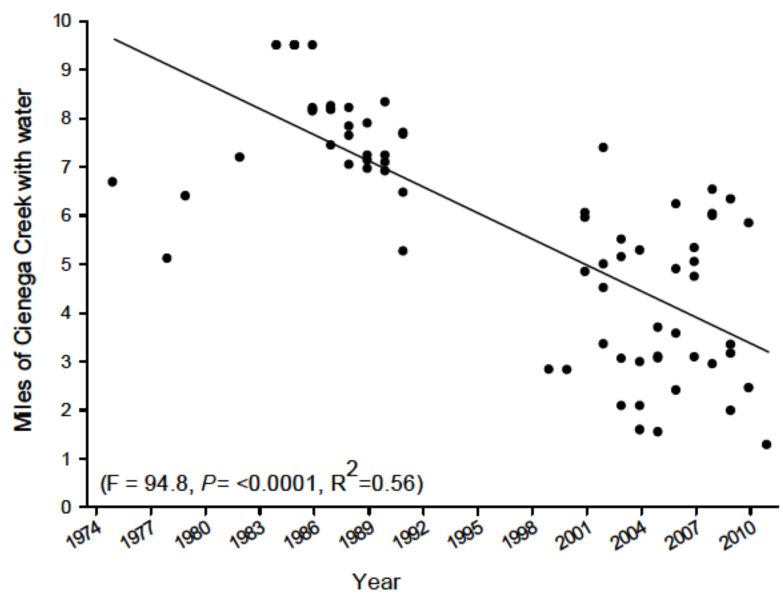


Figure 8. Extent of stream flow at Cienega Creek Natural Preserve (from Powell 2013) has both declined (solid line shows linear regression model) and shown more intra-annual variability. Maximum flow extent is 9.5 miles.

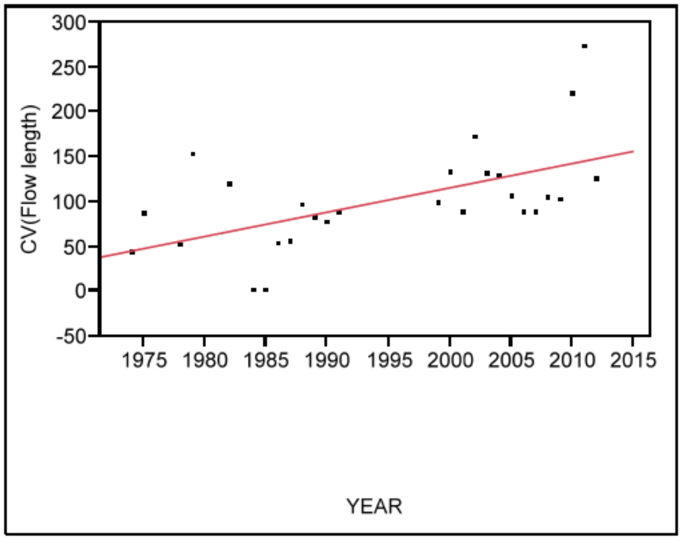


Figure 9. An increase in the coefficient of variation of streamflow length demonstrates that streamflow length is becoming increasingly variable over time. Increased variability can lead to instability of the system.

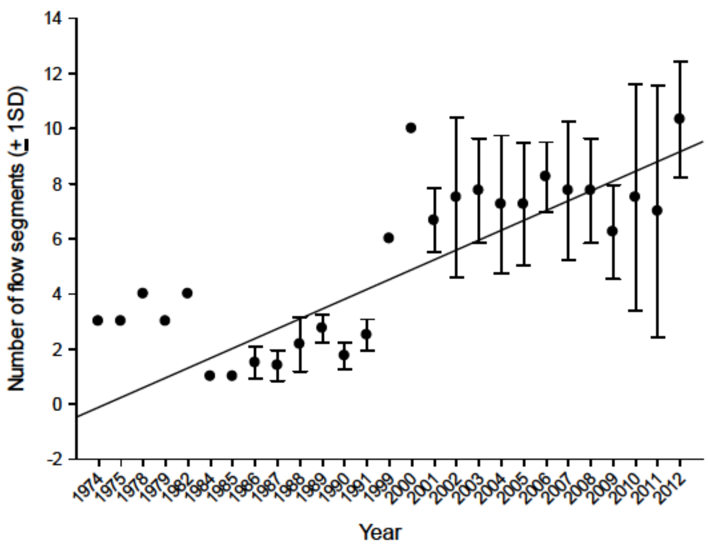


Figure 10. The number of streamflow segments has increased over time. As with flow length, increased variability can lead to isolation and loss of organisms that rely on open water, including Gila chub, Gila topminnow, and Huachuca water umbel. Analysis of variance test (solid line) shows this relationship to be significant ($F_{1,25}$= 11.8, P = 0.002, R^2 = 0.32).

Table 3. Results of multiple regression analysis on the relationship between number of flow segments that met the threshold ($\leq$1,085 feet) and other variables thought to influence the number of segments.

Effect	Estimate	F	P
Length of flow in Cienega Creek	51.1	19.5	<0.0001
Year	0.2	0.1	0.804
Month	6.0	1.6	0.217
Year*Month interaction	0.3	0.1	0.781

Discussion: Impacts on Species

Habitats of aquatic and mesic-riparian species in Cienega Creek and Davidson Canyon are decreasing in size and quality as the result of the reduction in the amount of available groundwater and surfacewater. This section highlights the likely impact on individual species, but looking broadly at the impacts of loss, fragmentation, and isolation that could result from threats to shallow groundwater and stormwater is instructive.

Cienega Creek is currently under stress. Water, the lifeblood of the system, is declining by every measure. There is a large and growing body of literature on the causes and consequences of ecosystems under stress (e.g., Odum 1985, Rapport et al. 1998, Rapport and Whitford 1999, Scheffer et al. 2001, Folke et al. 2004) and key among these findings is that as threats increase, habitat extent and quality declines, variability increases, and a system is more susceptible to threats that would not otherwise have impacted the system, such as loss of native species, increase in invasive species, etc. In essence, the system becomes less resilient.

Of course, the current state of Cienega Creek has nothing to do with the Rosemont mine. Yet it should be clear from the data presented here that any future impacts to the surface and groundwater resources of the system could have a far greater impact than indicated by either Rosemont or the permitting agencies. Another way to look at the impacts of the Rosemont mine is to say that if it was already built and impacting groundwater during the current drought, then Cienega Creek could lose as much as 37% of the baseflow during the critical pre-monsoon season, potentially leading to severe population declines of T&E species.

Gila topminnow. The habitat of Gila topminnow can be a broad range of water types such as pools and riffles and seem to prefer stream margins. Preferred habitats contain dense mats of algae and debris, usually along stream margins or below riffles, with sandy substrates sometimes covered with organic mud and debris. The largest natural populations of Gila topminnow occur in Cienega Creek (Bodner et al. 2007). Gila topminnow have recently been monitored at the CCNP (Marsh et al. 2009, 2010)[7] and in some areas are found in stream reaches that often classify as intermittent based on PAG wet-dry data, as well as perennial reaches. The aquatic habitats in the CCNP are a patchwork of disconnected habitat patches that are only connected during high-volume stormflows.

The modeled decline of habitat highlighted in this report, which includes reduction in the amount of baseflow and surface water extent (Figures 1-3, Table 1) and increase fragmentation (Table 3) will impact this species, especially during this critical June period. For the topminnow, which can live in very shallow water, further fragmentation and loss of key refugia could have significant impacts. This is acknowledged by the U.S. Fish and Wildlife Service in the Biological Opinion (U. S. Fish and Wildlife Service 2013; page 287), but their analysis is qualitative in nature. The results presented here can help a more robust analysis.

Gila Chub. Gila chub have an affinity for deeper pools (as compared to Gila topminnow) in slow velocity water and are often associated with cover such as undercut banks, root wads, and instream debris piles. At the CCNP, their distribution is largely restricted to three pools, one of which is found in an intermittent reach (Figure 11). The drawdown of the aquifer that supports critical base flows for this species will likely reduce the size and volume of the pools in which the Gila chub live.

The data in this report (e.g., Figures 1-3, Table 1) should cause a reevaluation of the impacts of groundwater decline for this species. For the Gila chub, the U.S. Fish and Wildlife Service (2013, page 267) use the analysis by Westland Resources Inc. (2012) as a basis for determination of impact. As we have noted, that report underestimated impacts to stream reaches. Our report points to a need to recognize that if drawdowns eliminate the shorter, persistent reaches, then recolonization of intermittent aquatic habitats when joined by flooding will depend on fewer, more widely spaced perennial refugia. Also, as drawdown occurs, occupied Gila chub pools will reduce in surface water depth, thereby leading to a possibility of increased water temperatures. This could be a problem for this species (and not for Gila topminnow) because of their lower tolerance of high water temperatures (Carveth et al. 2006).

---

[7] These studies have noted numbers of Gila chub caught at the CCNP but the survey methods were not designed to estimate populations or even catch-per-unit effort. The Biological Opinion (U. S. Fish and Wildlife Service 2013) does not take this into account (page 254; though it states later [page 273] that the methods were not meant to enumerate trends). Though restricted to a few pools at CCNP, there are many more individuals than are reported by these monitoring efforts.

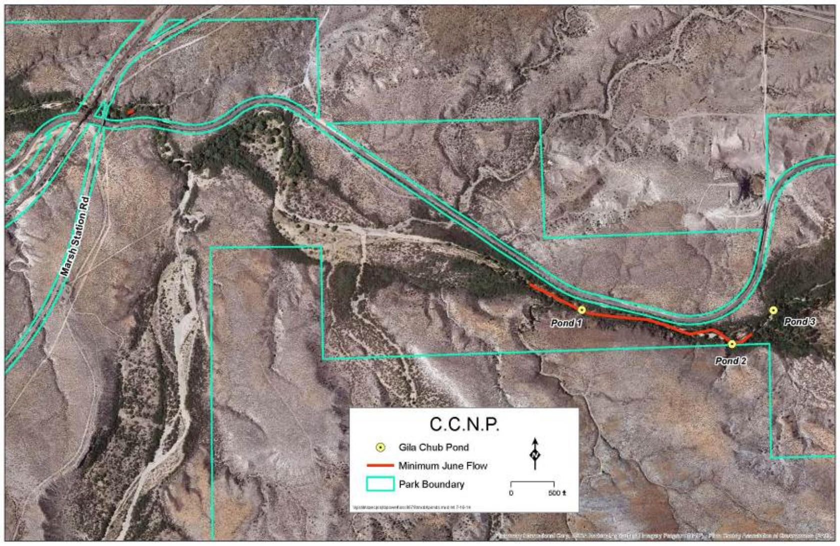


Figure 11. Location of pools with Chub in relation to areas that have a minimum June flow. Pool 3 is located in an intermittent stretch of the Creek, but that pool is very dynamic, as are the presence of chub. Pool 1 and Pool 2 contain chub more consistently. Figure by Mike List (Pima County IT).

Figure 12. This adult northern Mexican gartersnake was found feeding on lowland leopard frog tadpoles at the Cienega Creek Natural Preserve on June 13, 2014. Predicted surface water declines because of the mine would impact the extent of habitat and the species' primary food sources: fish and tadpoles. Photograph by Julia Fonseca.

Northern Mexican Gartersnake. This species is highly aquatic and only ventures a short distance away from water for hibernation and occasionally for foraging (U.S. Fish and Wildlife Service 2014). Its diet primarily consists of small fish and frogs, which are found on the CCNP. Though observations of this species at the Preserve are very rare, they have been found there (Rosen and Schwalbe 1988, Rosen and Caldwell 2004), including as recently as June 13, 2014 when one adult was confirmed (Figure 12). An additional juvenile may also have been found, but no positive identification was made. The historical decline in the amount and extent of surface water (Figure 8) and the modeled decline in these resources as a result of the mine (Figures, 1-3, Tables 1, 2) will impact the extent of habitat and the aquatic prey base upon which these species depend. The northern Mexican gartersnake was not a part of the consultation for the biological opinion for the mine (U. S. Fish and Wildlife Service 2013), but will be part of the reinitiated consultation process (letter from USFWS Field Supervisor Steve Spangle to Forest Service Supervisor Jim Upchurch, dated May 16, 2014). The presence of the species and the modeled impacts should be considered as part of those deliberations.

Yellow-billed cuckoo. The yellow-billed cuckoo prefers large willow and cottonwood trees for nesting and foraging. The status of the population at the Cienega Creek NP is not entirely certain, but a single-pass survey by Powell (*unpublished data*) in 2013 revealed at least 11 individuals. Based on the work by Corman and Magill (2000), we know that the yellow-billed cuckoos populations at the CCNP and on the Las Cienegas NCA are some of the largest among small creeks in Arizona. Unfortunately, the slow desiccation of some areas of the CCNP in the last years has significantly impacted the gallery riparian forest on which the cuckoo depends for nesting, even as other forest patches continue to gain canopy volume and height (Figure 12, Swetnam et al 2013).

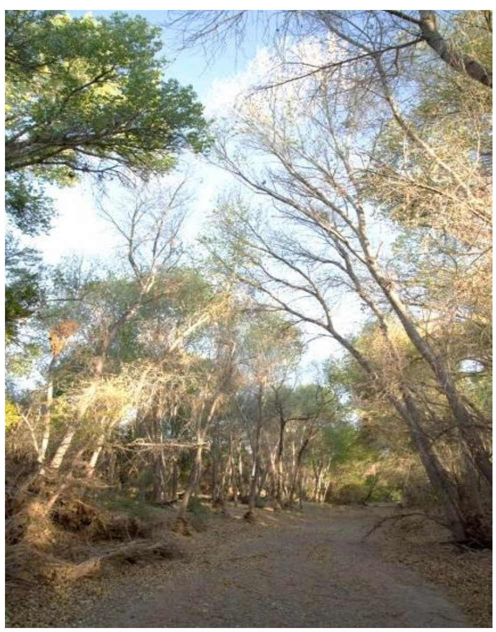


Figure 12. Photo from Cienega Creek NP showing impacts of the current drought on the thinning canopy of cottonwood trees, the primary tree used for nesting and foraging by the yellow-billed cuckoo. Loss of groundwater from the Rosemont mine will exacerbate this problem. Photo taken on May 30, 2014 very close to where yellow-billed cuckoos were detected in 2013. Cuckoos would be unlikely to nest in an area with such an open canopy.

There has been a considerable amount of research on cottonwood and willow trees as it relates to depth to water and tree species composition in the desert southwest (e.g., Stromberg et al. 1996, Horton et al. 2001, Harner and Stanford 2003, Stromberg et al. 2007, Hidalgo et al. 2009, Merritt and Poff 2010). The work by Lite and Stromberg (2005) and Leenhouts et al. (2006) is particularly relevant to the situation at CCNP. Studying the threshold between groundwater depth and flow permanence on the presence and vigor of cottonwood trees, Lite and Stromberg (2005) found that flow permanence was the single greatest hydrologic predictor for the presence of cottonwood trees. Flow permanence of 76% was viewed as important, as was depth to water of approximately 3m, a result that that has been found by other studies (Horton et al. 2001). Lite and Stromberg (2005) believe that flow permanence is probably a surrogate for other (not studied) hydrological characteristics, but it provide a good starting place for thinking about how changes in groundwater drawdowns will impact the habitat of yellow-billed cuckoos. Flow permanence is a particularly helpful measure because it is easily observed, as opposed to depth to water, which can be measured at various wells but varies spatially. Pima County is currently pursuing an analysis of surface water extent and vegetation change over time. We hope to have results in the coming weeks.

Huachuca water umbel. The Huachuca water umbel requires permanent water and grows on the margins of streams. First detected in 2001 within patches of cattail and bulrush (Engineering and Environmental Consultants Inc. 2001), the umbel appeared to have colonized a location in the CCNP from larger populations upstream. The cattail-bulrush wetland in which umbel colonized was considered a perennial reach in 2000-2001, but subsequently desiccated because of the headcut, which was studied intensively by the Pima Association of Governments (PAG; 2009b). The PAG study included piezometers which documented the loss of near-surface waters and dewatering of sediment during pre-monsoonal droughts that precede headcutting during subsequent floods. The dewatering of sediment during pre-monsoonal months likely rendered umbel habitat unsuitable, even if no headcutting occurred.

The umbel has not been seen in the CCNP for a number of years, in spite of casual searches during quarterly walk-throughs, and a dedicated search during 2013. Colonization events may be infrequent, and with reductions in areas of permanent water from the impacts of the Rosemont mine, there will be less available habitat for natural establishment and persistence.

Conclusions

To our knowledge, this is the first attempt to use water resource data collected at the CCNP and Davidson Canyon to better understand the range of potential impacts that the mine might have on water resources and the T&E species that rely on this resource. Our analysis show:

- The statistical relationship between depth to water and baseflow and streamflow extent is outstanding for the paired relationships of Cienega Creek and Cienega Well (Figure 1) and Davidson Canyon and Davidson Canyon #2 well (Figure 3);

- These data, along with a critique of Rosemont-sponsored data collection efforts that relied on faulty data and assumptions, provide the strongest support to date for the connection between surface water and groundwater resources in Davidson Canyon and Cienega Creek.

- Using models that express this relationship, we show that previous modeling efforts (WestLand Resources Inc. 2012) significant underestimated the loss of streamflow length that could result from the mine. We also estimate, for the first time, the amount and percentage of baseflow that will be lost with a drawdown of the aquifer the supports the aquatic and riparian resources of lower Cienega Creek and Davidson Canyon.

- Groundwater drawdowns of the magnitude predicted and within possibility show that there will be significant and measurable impacts on the extent of surface water and habitat for the Gila topminnow and Gila chub (Table 1) and other species (Tables 1 and 2). This is particularly critical during June when the creek is at its lowest baseflow and extent;

- Fragmentation of aquatic habitat shows and inverse relationship to flow extent (Table 3); that is, as extent declines, fragmentation will increase. This will lead to additional take and threat to T&E species that has not been previously considered;

- There is still considerable uncertainty about the impacts of surface water diversions into Cienega Creek and Davidson Canyon. Developing a better understanding of these impacts will allow a more refined accounting of impact on the aquatic system of Cienega Creek and Davidson Canyon and the species that call these places home.

Literature Cited

Arizona Department of Environmental Quality. 2014. Clean Water Act Section 401 Water Quality Certification, U.S. Army Corps of Engineers Public Notice / Application No.: SPL-2008-00816-MB ADEQ LTF 55425. Phoenix, Arizona.

Bodner, G., J. Simms, and D. Gori. 2007. State of the Las Cienegas National Conservation Area: Gila topminnow population status and trends 1989-2005. The Nature Conservancy, Tucson, Arizona.

Carveth, C. J., A. M. Widmer, and S. A. Bonar. 2006. Comparison of upper thermal tolerances of native and nonnative fish species in Arizona. Transactions of the American Fisheries Society 135:1433-1440.

Corman, T. E. and R. T. Magill. 2000. Western yellow-billed cuckoo in Arizona: 1998 and 1999 survey report to the Nongame and Endangered Wildlife Program, Arizona Game and Fish Department. Technical Report 150, Phoenix, Arizona.

Engineering and Environmental Consultants Inc. 2001. Final report: Huachuca water umbel surveys of Cienega Creek Preserve, Bingham Cienega Preserve, and La Cebadilla Property, Pima County, Arizona. Report to the Pima County Regional Flood Control District.

Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C. S. Holling. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. Annual Review of Ecology Evolution and Systematics 35:557-581.

Harner, M. J. and J. A. Stanford. 2003. Differences in cottonwood growth between a losing and a gaining reach of an alluvial floodplain. Ecology 84:1453-1458.

Hidalgo, H. G., T. Das, M. D. Dettinger, D. R. Cayan, D. W. Pierce, T. P. Barnett, G. Bala, A. Mirin, A. W. Wood, C. Bonfils, B. D. Santer, and T. Nozawa. 2009. Detection and attribution of streamflow timing changes to climate change in the western United States. Journal of Climate 22:3838-3855.

Horton, J. L., T. E. Kolb, and S. C. Hart. 2001. Responses of riparian trees to interannual variation in ground water depth in a semi-arid river basin. Plant Cell and Environment 24:293-304.

Leenhouts, J. M., J. C. Stromberg, and R. L. Scott, (eds.). 2006. Hydrologic requirements of and consumptive ground-water use by riparian vegetation along the San Pedro River, Arizona. U.S. Geological Survey Scientific Investigations Report 2005-5163, Reston, VA.

Lite, S. J. and J. C. Stromberg. 2005. Surface water and ground-water thresholds for maintaining *Populus-Salix* forests, San Pedro River, Arizona. Biological Conservation 125:153-167.

Marsh, P. C., B. R. Kesner, J. A. Stefferud, and S. E. Stefferud. 2009. Fish monitoring of selected streams of the Gila River Basin, 2008. Unpublished report to the Bureau of Reclamation, Phoenix Area Office, Phoenix, Arizona.

Marsh, P. C., B. R. Kesner, J. A. Stefferud, and S. E. Stefferud. 2010. Fish monitoring of selected streams of the Gila River Basin, 2009. Unpublished report to the Bureau of Reclamation, Phoenix Area Office, Phoenix, Arizona.

Merritt, D. M. and N. L. Poff. 2010. Shifting dominance of riparian *Populus* and *Tamarix* along gradients of flow alteration in western North American rivers. Ecological Applications 20:135-152.

Montgomery and Associates Inc. 2010. Revised report: Groundwater flow modeling conducted for simulation of proposed Rosemont pit dewatering and post-closure, Vol. 1: Text and tables. Prepared for Rosemont Copper. Tucson, Arizona.

Myers, T. 2014. Technical memorandum: Review of surface water/Groundwater relations in the Cienega Creek watershed. Memorandum to the Pima County Regional Flood Control District. Dated: June 25, 2014.

Odum, E. P. 1985. Trends expected in stressed ecosystems. Bioscience 35:419-422.

Pima Association of Governments. 2005. Unique Waters nomination for Davidson Canyon. Prepared for the Pima County Regional Flood Control District, Tucson, Arizona.

Pima Association of Governments. 2009a. Cienega Creek Natural Preserve surface water and groundwater monitoring. Annual report for the 2007-2008 fiscal year. Unpublished report to the Pima County Regional Flood Control District, Tucson, Arizona.

Pima Association of Governments. 2009b. Evaluation of riparian habitat and headcutting along Lower Cienega Creek. Unpublished report to the Arizona Water Protection Fund.

Pima Association of Governments. 2011. Surface water and groundwater monitoring project- PAG annual report, Fiscal year 2009-2011. Unpublished report prepared by the Pima County Regional Flood Control District, Tucson, Arizona.

Pima County. 2012. Comments on the draft Environmental Impact Statement for the Rosemont Mine. Comments provided to Jim Upchurch, Forest Supervisor, Coronado National Forest, Tucson, Arizona.

Pima County. 2013. Pima County comments- Rosemont Copper Mine Preliminary Administrative Final Environmental Impact Statement. Comments provided on August 14, 20013 to Jim Upchurch, Forest Supervisor, Coronado National Forest, Tucson, Arizona.

Powell, B. F. 2013. Trends in surface water and ground water resources at the Cienega Creek Natural Preserve, Pima County, Arizona. Unpublished report of the Pima County Office of Sustainability and Conservation, Tucson, Arizona.

Rapport, D. J. and W. G. Whitford. 1999. How ecosystems respond to stress - Common properties of arid and aquatic systems. Bioscience 49:193-203.

Rapport, D. J., W. G. Whitford, and M. Hilden. 1998. Common patterns of ecosystem breakdown under stress. Environmental Monitoring and Assessment 51:171-178.

Rosen, P. C. and D. J. Caldwell. 2004. Aquatic and riparian herpetofauna of Las Cienegas National Conservation Area, Pima County, Arizona. Unpublished report to Pima County Board of Supervisors for the Sonoran Desert Conservation Plan, Tucson, Arizona.

Rosen, P. C. and C. R. Schwalbe. 1988. Status of the Mexican and narrow-headed garter snakes (*Thamnophis eques megalops* and *Thamnphis rufipunctatus*) in Arizona. Unpublished report from Arizona Game and Fish Department to U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.

Stromberg, J. C., S. J. Lite, R. Marler, C. Paradzick, P. B. Shafroth, D. Shorrock, J. M. White, and M. S. White. 2007. Altered stream-flow regimes and invasive plant species: The *Tamarix* case. Global Ecology and Biogeography 16:381-393.

Stromberg, J. C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: The San Pedro River, Arizona. Ecological Applications 6:113-131.

SWCA Enivironmental Consultants. 2012. Presentation made to U.S. Fish and Wildlife Service and U.S. Forest Service to convey detailed information regarding the Seeps, Springs, and Riparian Impacts Analysis in the Rosemont EIS, in order to inform the USFWS Section 7 consultation process. November 12, 2012.

Swetnam, T. and B. F. Powell. 2010. Example of the use of LiDAR for monitoring vegetation characteristics: An example from the Cienega Creek Nature Preserve. Unpublished report to the Pima County Office of Conservation Science and Environmental Policy, Tucson, Arizona. Accessed on March 25, 2012 from: http://www.pima.gov/cmo/sdcp/Monitoring/PDF/Supplement_D_Examing_Use_of_LiDAR_For_Monitoring_Vegetation.pdf.

Tetra Tech. 2010a. Davidson Canyon hydrogeologic conceptual model and assessment of spring impacts. Tetra Tech Project No. 114-320869. Prepared for Rosemont Copper. Tucson, Arizona.

Tetra Tech. 2010b. Regional groundwater flow model, Rosemont Copper Project. Tetra Tech Project No. 114-320874. Tucson, Arizona.

U. S. Fish and Wildlife Service. 2013. Final biological and conference opinion for the Rosemont Copper Mine, Pima County, Arizona. Appendix F of the Final environmental impact statement for the Rosemont Copper project: A proposed mining operation, Coronado National Forest, Pima County, Arizona. U.S. Department of Agriculture, Forest Service, Southwestern Region. Document number MB-R3-05-6a.

U.S. Fish and Wildlife Service. 2014. Endangered and threatened wildlife and plants; Threatened status for the northern Mexican gartersnake and narrow-headed gartersnake. Federal Register Vol. 79 No. 130.

U.S. Forest Service. 2013. Final environmental impact statement for the Rosemont Copper project: A proposed mining operation, Coronado National Forest, Pima County, Arizona. U.S. Department of Agriculture, Forest Service, Southwestern Region. Document number MB-R3-05-6a.

WestLand Resources Inc. 2011. Rosemont project: Effects of surface water and groundwater diversion on offsite riparian habitats in Davidson Canyon. Report to the Rosemont Copper Company, Tucson, Arizona.

WestLand Resources Inc. 2012. Rosemont project: Potential effects of the Rosemont project on lower Cienega Creek. Report to the Rosemont Copper Company, Tucson, Arizona.

Zeller, M. E. 2011. Predicted regulatory (100-Yr) hydrology and average-annual runoff downstream of the Rosemont Copper Project. Tucson, Arizona.

From:	Deborah Haro
To:	"jupchurch01@fs.fed.us"
Cc:	ledmunds@fs.fed.us; " (Jean_Calhoun@fws.gov)"; "Marjorie.E.Blaine@usace.army.mil"; Blumenfeld, Jared; "tshannon@blm.gov"; Ally Miller; Andres Cano; Andres Vargas; Anissa Ramirez; Benny Gomez; Evangelina Quihuis; Frank Franco; Jeannie Davis; Jennifer Cabrera; Jennifer Eckstrom; Jennifer Wong; Joseph Cuffari; Keith Bagwell; Kiki Navarro; Marcos Perez; Michael Lundin; Paula Maxwell; Ramon Valadez; Ray Carroll; Richard Elias; Rosie Alexander; Sharon Bronson; Shirley Lamonna; Tom Ward
Subject:	Rosemont Mine Supplemental Information Report
Date:	Wednesday, July 16, 2014 4:07:44 PM
Attachments:	ju-rosemont adeq 401 certification.pdf

Hello Mr. Upchurch,

Please see the attached correspondence from Mr. Huckelberry regarding Rosemont Mine. The original letter will be provided to you via US mail.

Thank you,
Debbie

Deborah Haro
520-724-8770
520-770-4201 Right Fax
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
Pima County Administrator's Office
130 W. Congress Street, Floor 10
Tucson, Arizona 85701
Deborah.Haro@pima.gov

COUNTY ADMINISTRATOR'S OFFICE
PIMA COUNTY GOVERNMENTAL CENTER
130 W. CONGRESS, FLOOR 10, TUCSON, AZ 85701-1317
(520) 724-8661 FAX (520) 724-8171

C.H. HUCKELBERRY
County Administrator

July 16, 2014

Jim Upchurch, Forest Supervisor
Coronado National Forest
300 W. Congress Street
Tucson, Arizona 85701

Re: **Rosemont Mine Supplemental Information Report**

Dear Mr. Upchurch:

Thank you for the invitation to participate in the hydrology working group meeting in June. As a result of this meeting, our staff provided new information for your decision via presentations and posting to the SWCA folder established for the group:

- Pima Association of Governments data showing the close relationship between groundwater depths to wetted reach lengths along lower Davidson Canyon;
- Pima County statistical analyses of wetted reach lengths along Cienega Creek based on a comprehensive analysis of long-term precipitation, stream flow, and groundwater records for the Cienega Creek Natural Preserve (Powell 2013).
- Arizona Department of Environmental Quality (ADEQ) report on Cienega Creek longitudinal profiles, as requested.

In addition, the US Environmental Protection Agency provided you, the hydrology group, and the US Fish and Wildlife Service a copy of our comments regarding ADEQ's draft Section 401 certification, which takes issue with some of the key assumptions that underlie the Final Environmental Impact Statement's (FEIS's) conclusions regarding effects to Davidson Canyon. These comments included a new interpretation of Rosemont's isotopic data by Dr. Chris Eastoe that differs from conclusions provided by Rosemont's consultants.

Since the hydrology meeting, our team has reviewed the following new materials that were discussed at the meeting. Detailed comments on the documents are attached for your consideration; but, briefly, our review is as follows:

- *Sensitivity Analysis for FEIS Streamflow Impact Assessment* (SWCA, June 6, 2014) and *Depth of Flow Information on Cienega Creek and Empire Gulch* (SWCA, October 2013). In general, there is too much variability in depths of flow along upper Cienega Creek to draw conclusions based on the stream gage, let alone on its tributaries.
- *Potential effects of the Rosemont Project on Lower Cienega Creek* (WestLand, November 14, 2012). We agree there is a positive relationship of wetted stream length and depth to water. However, WestLand's use of all seasonal data resulted in weak conclusions, and we take issue with their conclusions about streamflow length and discharge rates. Pima County's review and analysis of the same data (attached) provides a more robust and comprehensive determination of effects to aquatic habitat and threatened and endangered species than the WestLand report. We believe our new report provides the environmental baseline at the Cienega Creek Natural Preserve for your decision and the best available science for the US Fish and Wildlife Service's deliberations on Huachuca water umbel, Gila chub, Gila topminnow, Mexican garter snake, yellow-billed cuckoo and other species that inhabit the Preserve.
- *Review of USFS Model and an Alternative Approach to Inform the Effects of Groundwater Drawdown on Cienega Creek* (Rosemont June 6, 2014). We have not received an updated version of this document, but Dr. Myer's comments on the June 6, 2014 report are attached. Pima County requests that the final Rosemont report be peer reviewed by Pima County and others. In general, the eight data points provided by wet/dry data are totally inadequate for drawing conclusions about the extreme ends of probability distributions. The correlation between flows and flow lengths was non-significant. The attached review by Dr. Tom Myer's provides a road map for the type of information that could be gathered to make informed conclusions about effects in the Empire Gulch/Upper Cienega area.

The key results of our analyses are that:

1. There is an important and highly statistically significant link between surface water flow extent and groundwater resources in Lower Cienega Creek and Davidson Canyon. The correlations found in our new analyses are so

significant, in fact, that their possibility of occurring by chance is nearly impossible.

2. Analyses by WestLand, TetraTech and SWCA have consistently underestimated the length of streamflow in Cienega Creek and Davidson Canyon that will be impacted by the mine.
3. The net result will be a loss of habitat and take of endangered species that exceeds previous considerations.

I believe the Forest Service cannot ignore this information. In the spirit of cooperation evident in the working group meeting, I would appreciate your response as to whether the Forest Service will consider this new information in revising conclusions regarding effects to Davidson Canyon and Lower Cienega Creek as you prepare your Supplemental Information Report.

Sincerely,

C. H. Huckelberry
County Administrator

CHH/mjk

Attachment

c: The Honorable Chair and Members, Pima County Board of Supervisors
Jean Calhoun, Assistant Field Supervisor for Southern Arizona, US Fish and Wildlife Service
Tim Shannon, District Manager, US Bureau of Land Management
Marjorie Blaine, Senior Project Manager, US Army Corps of Engineers
Jared Blumenfeld, Region IX Administrator, US Environmental Protection Agency

Technical Memorandum

Review of Surface Water/Groundwater Relations Memoranda in the Cienega Creek Watershed

June 25, 2014

Prepared by: Tom Myers PhD, Hydrologic Consultant, Reno, NV

The Forest Service used analyses by SWCA (2013) to complete a risk analysis of the potential for drawdown to increase the length of dry stream in the upper Cienega Creek basin. Rosemont Mining (2014) presented an alternative analysis in objection to the SWCA risk analysis. SWCA responded with a sensitivity analysis (SWCA 2014). This memorandum reviews these three memoranda and recommends a new method for estimating the effect of drawdown on the Cienega, primarily because neither of the methods reviewed have much basis in hydrologic reality. Additionally, this memorandum reviews Westland (2012), which estimates changes in wetted stream length for the lower Cienega Creek, and recommends an alternative means of estimating changes in that stream reach.

Review of SWCA 2013

SWCA prepared a risk assessment to address riparian impacts, assessing the range of potential drawdown and the impacts that could be caused by that drawdown. They gathered a series of detailed stage and daily flow measurements for the USGS gage on Cienega Creek near Sonoita (#09484550). The gage is a v-notch weir embedded in a concrete wall. There had been a period of zero flow during May/June 2010. Zero flow means no flow passing the gage, but others have observed that pools and the channel above the gage may have water; the photo of the gage in SWCA (2013) shows the v-notch to be above the channel thalweg and that the weir causes a pool to form above the location. Also, the gage is near a bedrock constriction so that groundwater flowing along the alluvium beneath the stream is forced to the surface. They also had 27 depth and flow measurements collected at various locations in the upper Cienega Creek area.

SWCA used the rating curve to convert flows at the gage to the “depth of water” at the gage. Importantly, the depth at the gage controls the depth in the channel only to nearest upstream riffle, where the flow passes through critical depth. Backwater from the weir only affects flow depth to that point.

SWCA compares the 29 point depth measurements throughout the watershed to the “median monthly water depth” at the gage. The point of that comparison is unclear, especially since many of the spot measurements are from the 1990s before the data used to determine the gage station median. Ostensibly the comparison of point flow depths with the gaged depth in Table 2 provides information about how the depth at a few locations compares to the gaged depth.

The comparison of spot measurement depth with median monthly depth at the gage in Figure 4 is completely meaningless because, as specified by SWCA, "channel geometry and flow characteristics are highly variable, even with short distances". Flow depth along the profile probably varies over several feet along a stream profile, and the reason for having a depth measurement at a given location is not provided - the choice and resulting depth seems to be random. Yet, SWCA states that "use of the stream gage as a surrogate for all of Upper Cienega Creek seems reasonable as an approximation of typical conditions along Upper Cienega Creek", even though they also recognize that **"actual impacts … would depend on the specific channel geometry, hydraulic connection with the regional aquifer, and riparian vegetation characteristics at a specific location".** These characteristics would likely cause the water level at random reaches through the watershed to vary much more than behind the v-notch weir, which are very controlled conditions.

Flow at the gage is an indicator of conditions in the watershed, meaning basically whether the watershed is wet or dry, but there is too much variability to glean any information from a perceived relationship of gage depth with spot depths through the watershed.   This includes generalizing the potential impacts. The use of the gage for tributary impacts is even more dubious.

SWCA estimated the effects of tributaries Empire Gulch and Gardner Canyon by considering that a drawdown at these tributaries of 0.3 feet will cause those tributaries to go dry and stop contributing flow – essentially an on/off switch that eliminates 11 or 26% of the flow in Cienega Creek. The 0.3 feet is based on the median flow depth at the gage during the critical May/June period. They provide no analysis but merely assume this relationship which is ultimately meaningless. Even if there was a 1:1 correspondence between drawdown and flow depth (there is not), no explanation was made of why 0.3 feet of drawdown will eliminate that flow. No tributary flow measurements relate to the gage. Additionally, their assumption assumes that no underflow would discharge from the watershed, again without justification.

The details of the calculation are not reviewed because the concept illustrated in Figures 6 and 7 shows the basic calculation to be flawed. It assumes that a drawdown in the regional groundwater table, as determined from the model, can be translated 1:1 to drawdown of stream depth. This is incorrect for several reasons.

- Flow in Cienega Creek depends on conditions throughout the watershed above the point, not simply on the slope of the water table from the bank to the stream. For example, if the flow in the creek at a point is x cfs, and the reach near that point contributes y to that flow, lowering the slope controlling y will decrease that discharge. At the limit, the streamflow becomes x-y (if the bank slope reaches 0, yielding no discharge). The depth of water in the creek will be that corresponding to x-y. The effect that eliminating y from the flow will have depends on the magnitude of y in relation to x.

- It is average head in the stream that controls groundwater discharge to the creek. The stream depth changes along the profile but the head "seen" by the groundwater would be an average of that profile.
- Darcy's Law does not explain the flow into the stream from the banks in an unconfined aquifer. Rather, it is the Dupuit-Forcheimer discharge formula which ultimately described the discharge to the creek and describes a parabolic water surface to the creek. Discharge from the banks cannot be described based on a simple value of slope from some point on the banks to the creek. (This does not preclude a regression yielding a meaningful relation, but the parabolic shape of the water table renders the regression not useful beyond the range of the regression.)

Review of Rosemont 2014

Rosemont used length of wet stream data collected by BLM that SWCA apparently did not use. BLM collected the wetted stream length data during the dry season so that surface runoff should not have had an influence on the data (Rosemont 2014).

Rosemont fitted the wetted stream length data to various probability distributions so that they could use probability modeling to determine the probability of the stream being dry, or in probabilistic terms, the wetted stream length going to zero. There were just eight data points used, and the shortest wetted stream length is 4.7 miles, recorded in June 2013. Rosemont Table 12 presents results of a fit test showing that even the lowest test statistic, supposedly meaning the distribution that best fits the data, is not significant. Rosemont chose the log-normal and normal distributions because the test statistics were lowest. The following figures are from Rosemont (2014) and show the cumulative probability and the probability density for each of the chosen distributions. Their Figure 3 shows that the one percent cumulative probability is about 3.5 and 3.9 for the normal and lognormal distributions, respectively. That means that if the distributions accurately describe the wetted stream length, the return interval is 100 years for wetted stream length being less than 3.5 or 3.9 miles (probability of 0.01 corresponds to return interval if the wetted stream length can be considered an annual value, in this case the shortest length for the year). Rosemont Figure 4 shows that the probability of a wetted stream length being less than about 2.5 miles is much less than 1%.

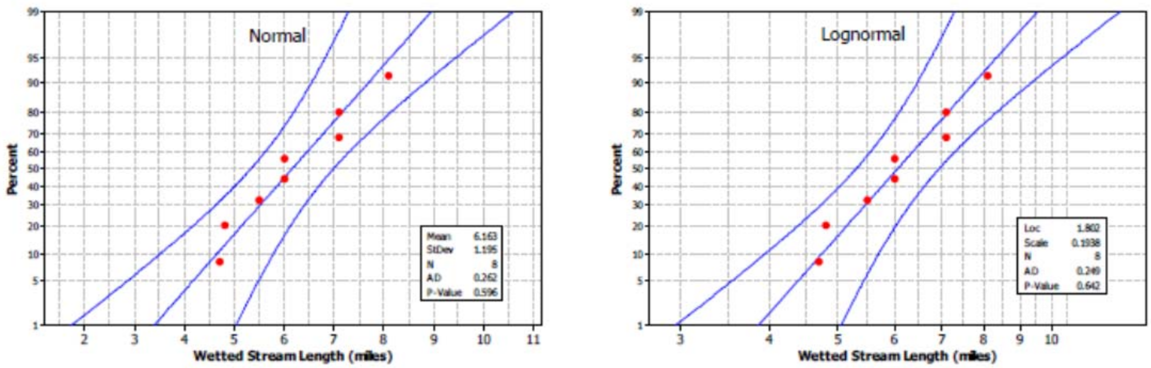


Figure 3. Probability plots with 95% confidence limits for normal and lognormal distributions.

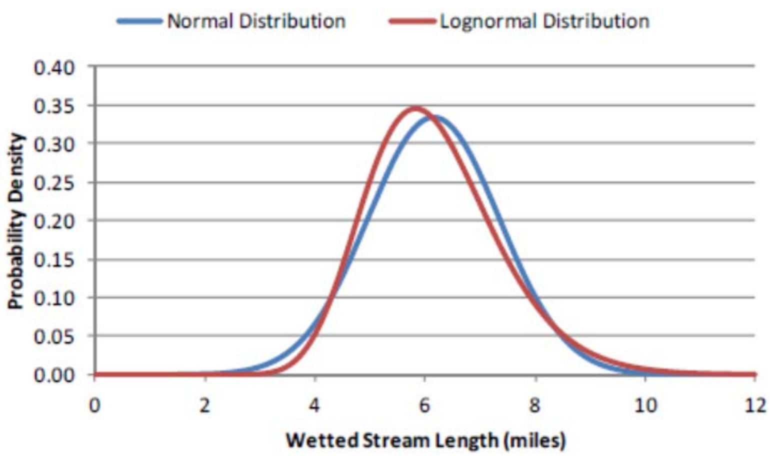


Figure 4. Probability density distribution for the normal and lognormal distributions fit to the BLM stream length data.

It is apparent that Rosemont used probability distributions far beyond their population of data (the population being the measured wetted stream lengths). **No results using such a distribution can be considered credible because it is far beyond the realm of model calibration**.

As part of their consideration of the Tetra-Tech model of decreased streamflow, Rosemont correlated flow of various metrics with the wetted stream length. As the following figure, snipped from Rosemont (2014) shows, the average of the gaged flow for the previous 170 days correlated the best, meaning that wetted stream length depends most on the previous six months climatology rather than short-term flows. The correlation was non-parametric and the linear regression completed to obtain 4.35 miles of stream length lost for a 1 cfs change in flow is inappropriate because linear regression assumes normality. **The R^2 is low and non-significant, therefore it is inappropriate and incorrect to claim that a 0.08 cfs predicted reduction in flow can translate into a 0.334 mile reduction in wetted stream length**. Additionally their Table 11 shows that the range in wetted stream length is from 4.7 to 8.1

miles which is a significant scatter in their regression (there is no scatter plot of the wetted stream length to any of the flow metrics). Finally, it is inappropriate because Tetra Tech's simulated flow rate would be base flow, not the 170-day flow preceding the wetted stream length measure as used in the equation.

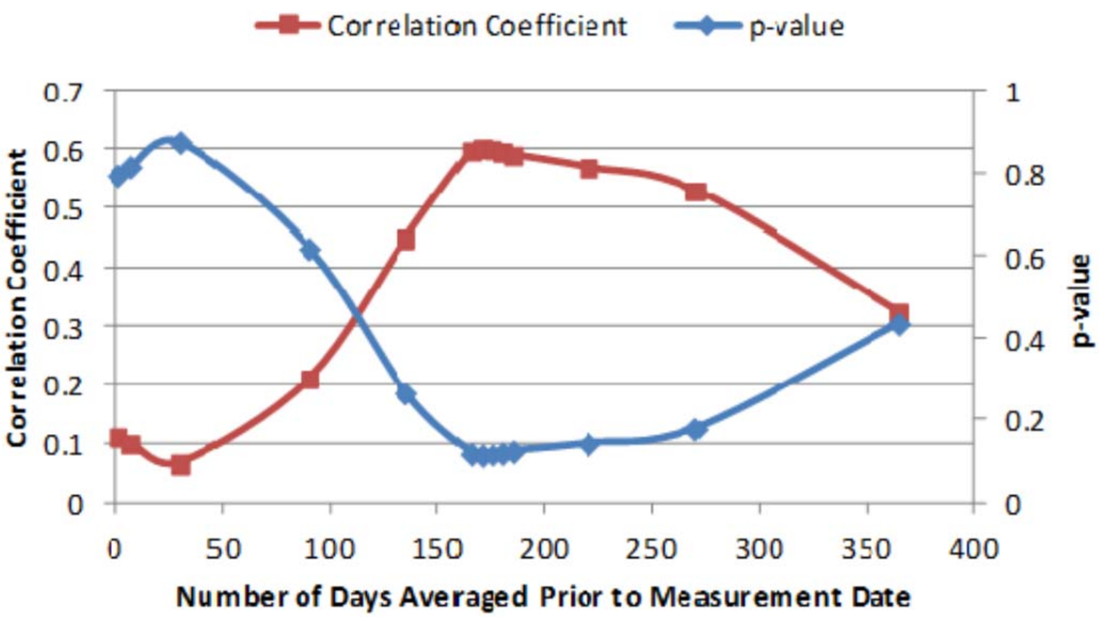


Figure 7. Correlation between flow and wetted stream length as a function of averaging period.

Simply, Rosemont used inappropriate flows and inappropriate probability distributions to estimate the probability of a dry stream. Their finding that even adding the drawdown causes essentially no chance of a dry stream is meaningless because it **is based on stretching empirical data far beyond their range**. The discussion of climate change effects simply adds one more bit of speculation to the calculation because they have to translate an annual streamflow reduction into an annual hydrograph when the effect in reality will vary through the year.

Considering the length of wetted stream length even during the driest period is 4.7 miles, it seems very unlikely that it would ever go dry under natural conditions. Because it is the primary discharge point for recharge within that watershed, it will continue to receive a discharge of groundwater until literally all of the recharge diverts toward the mine. This would require a drawdown sufficient to change the groundwater divide between the Cienega watershed and the proposed mine. The models all predicted drawdown through the watershed of less than 10 feet up to 1000 years from the end of mining. Thus, discharge to Upper Cienega Creek will be reduced because the gradient to the creek will be reduced.

The wetted stream length depends on both regional and local conditions and it is possible that drawdown will prevent regional groundwater discharge along some reaches. **The stream wetted length relates to gage data only if that the gage reflects watershed conditions**.

Summary

In summary, Rosemont claims the analysis depends on two major assumptions (Rosemont 2014, p 30), both of which are bad. The wetted stream length does not follow a distribution that allows estimates at the extreme. The scatter and low correlation of stream flow at the gage is poorly related to wetted stream length. No useful result appears to be gained from this analysis**. The only way to estimate the effect of drawdown on streamflow reductions and the length of wetted stream is to collect detailed empirical data and calibrate a local groundwater model of the surface/groundwater relations in the Cienega Creek, as described below.**

Review of SWCA 2014

This memorandum performs a sensitivity analysis of one key assumption in their 2013 streamflow analysis – the relationship of change in bank water level to the change in stream depth. They test the difference that a 1:5 and a 1:10 ratio of change in stream depth to bank ground level difference would make in the estimate of flow in the stream.

SWCA lists many assumptions that went into the original analysis. Several are problematic, such as the assumption of a 1:1 linear relationship between drawdown and loss of water depth as described above. Another very problematic assumption is that flow contribution from Empire Gulch and Gardner Canyon is binary, meaning that if flow at the mouth is zero then the contribution goes to zero. **This is incorrect because the contribution includes surface and underflow. Flow through the groundwater beneath the streambed will also contribute to flow in Cienega Creek because it may surface at some point downstream**.

It is also incorrect to assume that flow impacts, other than changes in flow rate, will migrate downstream to Lower Cienega Creek because there is a bedrock constriction at the gage. The contribution of the upper basin to the lower depends on the stream flow; the effect on groundwater in the Lower Cienega depends on how much recharges the alluvial aquifer, an amount which cannot be affected by drawdown because of the bedrock.

It is correct to state that “dry” conditions may occur while there are isolated pools with no surface flow between them. There could be subsurface flow.

Based on the above, there is not a simple linear relation of any ratio that can explain the change in discharge to the stream due to drawdown. Not infrequently, an iterative process using Darcy's Law and Manning's equation is used to estimate the change, but there are inherent inaccuracies due to the relation actually being nonlinear. So, based on the above, the sensitivity analysis completed by SWCA is meaningless.

Review of Westland (2012)

This analysis attempts to relate the wetted stream length of three different intermittent reaches of Lower Cienega Creek with the depth to water in various overbank wells. Ostensibly there is nothing wrong with the concept that the amount of flow in the creek relates to the depth to water in the wells. The regression lines explain from about 43 to 73% of the variance, so they have merit. The scatter plots do not suggest the correlation is spurious, although they indicate there is a huge scatter in the results. The scatter covers as much as 7000 feet for a two-foot change in depth to water; **obviously other factors affect the wetted stream length.** The confidence in the results of the regression analysis is very low, especially considering the prediction is for a drawdown in the overbank wells of about 0.1 feet. The predicted changes due the drawdown are two orders of magnitude less than the natural scatter in the data and should be given little credence.

The analysis in the second section concerning the potential effects due to surface water impoundment suffers from an error in concept. The estimate is that annual flow at the confluence of Cienega Creek and Davidson Canyon reduces by 12% of average flows[1]. This is likely to occur during large storm flows. Westland recognizes that the contribution of storm flows is to infiltration into the stream bank for later discharge to the stream. They assume that the contribution of Davidson Canyon annual flows to Cienega Creek is 24 percent but provide no basis for that assumption.

The regression of wetted stream length to flow rate at the confluence shows two different relations (Westland Figure 5), which Westland does not account for. At flows higher than 0.6 cfs, the relation appears linear. Below that point there is a huge scatter with wetted stream length ranging from less than 1000 to about 6000 feet. The data above 0.6 cfs controls the slope which due to the scatter is meaningless at 0.35 cfs, the assumed baseflow rate. They estimate the flow rate change due to the mine to be 12% of the 24% of the average 0.35 cfs baseflow, or 0.12x0.24*.35 = 0.01 cfs. This very low flow rate yields a very small estimated change in wetted stream length as the estimated reduction due to the mine.

The conceptual error is that the estimated flow reduction is of annual average flow and is not a reduction applied uniformly through the year. Changing storm flow changes the recharge characteristics in the floodplain aquifer, which could be a change in the dynamics of the aquifer that supports Lower Cienega baseflow. Total recharge could likely be much decreased as could

---

[1] **It is assumed this means flow in Cienega Creek, not just Davidson Canyon.**

the distribution of recharge along the stream reach. The changed dynamic render the regression equation even more unrepresentative of the stream than it had been previously.

Recommendation

Several alternative analyses could be done to improve the risk assessment, but each requires the collection of significant amounts of data. **It is simply not possible to use existing data provide a meaningful estimate of the risk to Cienega Creek from long-term drawdown.**

During baseflow conditions, those most likely to be affected by drawdown, surface water flow rates on Cienega Creek vary along the profile according where water flows into the stream and where it flows from the stream. Flow directions can reverse in very short distances based on the cross-sectional area and conductivity of the alluvial aquifer beneath the stream; there are likely reaches with no flow, the length of which depends on the depth of wet reaches up and downstream. Flow data along the entire reach can be related to the gage if accurate data on flows, gaining and losing reaches, and the length of dry reaches can be obtained.

Detailed synoptic surveys of the flow along the creek should be obtained over at least two baseflow periods (two to consider variability). Flow measurements should be obtained at the up- and downstream ends of each gaining reach, to allow an assessment of the amount of flow that enters and leaves the stream. Gaining and losing reaches may be estimated by measuring temperature change in the flow and in the substrate and by installing piezometers near the stream and in the substrate under the stream to assess small-scale gradients (see the USGS study of eastern Nevada for information on completing such a survey, http://nevada.usgs.gov/water/studyareas/springsnake.htm). In conjunction with these surveys, there should be piezometers installed in the stream bank to assess how the changes in channel depth or wetted stream length related to changes in water level in the banks. Piezometers would be needed on each side of the creek at spacing depending on the canyon characteristics. Two piezometers would partially explain changes in a reach, but the length of that reach depend on the alluvial aquifer characteristics being homogeneous.

Collected over a period of at least two years, this data could be related to gaging station depth record to extend the record and complete a risk assessment. As part of the synoptic survey, detailed cross-section would be measured. Using these and the changes in flow rate, a water surface profile model such as HEC-RAS or HEC-2 could be used to estimate new flows and velocities. Or, the USFWS model PHABSIM (Physical Habitat Simulation) model could be used to assess changes caused by drawdown.

It would also be possible use this data to calibrate a detailed local-scale groundwater model of the alluvial aquifer and the stream depth. This model should include data relating it to the regional aquifer. Once calibrated, the results of the regional models could be imposed to determine the frequency and length of stream that goes dry due to mine development.

The potential changes to flow in Lower Cienega Creek are much greater due to the change in runoff from Davidson Canyon. The first step to understanding these changes is to apply runoff changes to the annual runoff hydrograph and assess how the recharge to the alluvial aquifer will change. A simple numerical model could be developed to assess seasonal changes in the floodplain aquifer; calibration could be done with the existing wells. Decreased recharge due to runoff changes could then be applied to the model to assess changes in wetted stream length.

References

Rosemont Copper Co (2014) Review of USFS Model and an Alternative Approach to Inform the Effects of Groundwater Drawdown on Cienega Creek.

SWCA (2014) Memorandum: Sensitivity Analysis for FEIS Streamflow Impact Assessment.

SWCA (2013) Memorandum: Review of Available Depth of Flow Information on Cienega Creek and Empire Gulch and Protocol for Estimating Impacts to Streamflow. October 30, 2013.

Westland Resources (2012) Rosemont Copper Project: Potential Effects of the Rosemont Project on Lower Cienega Creek.

Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of the Cienega Creek Natural Preserve

Brian Powell[1], Lynn Orchard[2], Julia Fonseca[1], and Frank Postillion[2]

July 14, 2014

[1]Pima County Office of Sustainability and Conservation
[2] Pima County Regional Flood Control District

Suggested Citation
Powell, B., L. Orchard, J. Fonseca, and F. Postillion. 2014. Impacts of the Rosemont Mine on hydrology and threatened and endangered species of the Cienega Creek Natural Preserve. Pima County, Arizona

Cover Photo: End of flow for one section of Cienega Creek at the Cienega Creek Natural Preserve. May 2014.

Introduction

If constructed, the Rosemont mine will reduce streamflow and groundwater inputs into Cienega Creek and Davidson Canyon. The uncertainty and discussions have been about the magnitude of that impact and how much, if any, projected changes will compromise populations of threatened and endangered (T&E) species and their habitats (e.g., Tetra Tech 2010a, b, WestLand Resources Inc. 2011, Pima County 2012, SWCA Enivironmental Consultants 2012, Pima County 2013). This is a critical question; lower Cienega Creek (herein, Cienega Creek unless otherwise noted) in the Cienega Creek Natural Preserve (CCNP) and in Davidson Canyon[1] provide both a critical water supply to the Tucson Basin and are a refugia for aquatic and riparian plants and animals found in few other places in Pima County.

This report provides the most comprehensive evaluation of the extensive water resource data that has been collected at CCNP as it relates to potential impacts from the Rosemont mine. We focus first on developing robust predictive models, apply those models to estimate a range of impacts to baseflow and length of streamflow, question some past analyses and assumptions about the lack of connection between surfacewater and groundwater, highlight key uncertainties that inhibit our ability to understand the full breadth of impacts from the mine, and finally, we combine the water resources data with our best understanding of the distribution of habitat for the aquatic and riparian T&E species that currently occur or recently occurred at the CCNP to estimate loss of habitat as a result of the mine.

A Note About Models and Their Use. Previously, estimated effects of the proposed mine on streamflow—particularly in reaches of perennial or intermittent flow—have been addressed primarily through groundwater modeling (e.g., Montgomery and Associates Inc. 2010, Tetra Tech 2010b, SWCA Enivironmental Consultants 2012). These models have then been used to estimate impacts on species in Cienega Creek and its major tributaries (U. S. Fish and Wildlife Service 2013). The final environmental impact statement (FEIS; U.S. Forest Service 2013) for the Rosemont project states that predicting sub-foot scale drawdowns at great distance and time scales is "beyond the ability of these groundwater models, or any groundwater model, to accurately predict." Nevertheless, sub-foot model results were presented as a basis to determine mine impacts on Outstanding Arizona Waters in Davidson Canyon and Cienega Creek (WestLand Resources Inc. 2011, 2012) and to draw conclusions about effects on T&E species. In this report, we also use subfoot groundwater model results as the best available information, but draw different conclusions than those of WestLand (2011, 2012).

[1] In this report, data collected in Davidson Canyon refer to areas in the CCNP and/or in Pima County's Bar-V Ranch.

In striving to understand the potential impacts of water loss on these critical riparian areas and the T&E species they support, it is prudent to investigate a range of potential impacts in areas where the existing analysis is inadequate to provide the level of detail needed to understand the Rosemont projects' effects on the downstream environment. Analysis provided in this paper endeavors to aid in "informing the decision" by presenting a range of potential impacts based on empirical data systematically collected from wells and field excursions over several years (e.g., Pima Association of Governments 2009a, 2011). This analysis of well depth vs. baseflow and length of streamflow and other analyses in Cienega Creek and Davidson Canyon acknowledges the limitations of the groundwater models and presents a range of groundwater drawdown effects that are reasonable to consider given the uncertainties of groundwater models and natural variation experienced during the monitoring period at the CCNP.

Methods

Field Methods. To determine the loss of surface water, we first developed models using data from the depth of water in wells and baseflow and total length of streamflow at two sites: (1) Cienega Creek and (2) Davidson Canyon. Much of the data collection methods and location maps are summarized in Powell (2013). For this effort we used data collected as recently as 2014 (Cienega Creek) and 2013 (Davidson Canyon), the most up-to-date information that we could receive from the Pima Association of Governments, which collects the data. June data were used to determine the relationship between depth to groundwater and streamflow length from 2000-2014 for Cienega Creek, but for Davidson Canyon, all data were aggregated to model this relationship, in part because of the smaller sample size (sample collections were started in late 2005 at Davidson). June samples were selected for Cienega Creek for a number of reasons such as length of record and because streamflow length data represents a critical low-flow for the system. Depth to water was measured at the Cienega Well (Cienega Creek) and Davidson #2 Well (Davidson Canyon[2]). Depth to water in wells and mapping of streamflow length were always measured on the same day. We also developed models for the relationship between streamflow volume (cubic feet/second; herein referred to as baseflow), which is measured quarterly at the Marsh Station Bridge (again, see Powell 2013 for the more information) and depth to water at the Cienega Well. We used all quarterly sampling data from June 2001 to June 2014 for this analysis.

Data Analysis

[2] The Davidson #2 Well and streamflow reach are located in "Reach 2", as defined by Tetra Tech.

Relationship between streamflow, depth to groundwater, and baseflow. We used linear regression to model the relationship between depth to water (in feet) and streamflow length (in miles) and baseflow (ft^3/sec). To model these changes, we interpolated the regression model to predict what changes in the response variables (i.e., baseflow and streamflow length) would result from a lowering of the water table by 0.1, 0.2, and 0.25 feet. This represents a look at the potential impacts to baseflow and streamflow length if the modeled results in Montgomery and Associates Inc. (2010) and Tetra Tech (2010b) occur as predicted (0-0.1 feet drawdown at Cienega Well, 0.10-0.98 feet at Davidson Well[3] for streamflow length). At Cienega Creek we looked at scenarios where drawdown will be slightly greater than predicted by the models to describe potential impacts if model results are not accurate (e.g., 0.2 - 0.25 feet drawdown at Cienega Well). For baseflow estimates we calculated total annual acre feet of baseflow lost, as well as seasonal estimates. Because baseflow was measured four times per year, we assumed these flow estimates represented seasonal averages. We used the annual and seasonal average baseflow to estimate the percentage of baseflow that would be reduced from groundwater drawdown. We log-transformed flow volume data to fit assumptions of the normal distribution for the regression analysis.

Fragmentation of Flow. One of the concerns about the loss of streamflow length is that the stream may also become more fragmented, which might isolate populations of fish, in particular. Fish caught in small, fragmented reaches would be more susceptible to extirpation due to a variety of factors, including predation and of course, loss of habitat. To model this for Cienega Creek, we first calculated the number and length of individual stream reaches (derived from individual start and stop points collected in the field). We then calculate intra-annual summaries, including the coefficient of variation in stream length[4] and total number of flow length segments over time. Finally, we used the results of the modeled changes in streamflow length as a function of depth to water in wells to understand how this might further fragment the system. Based on the modeled results for a drawdown of 0.25 feet, we calculated the number of streamflow lengths measured from 2001-2012 (the most complete set of information for which four seasonal measurements are each year) that were equal to or less than the predicted loss in streamflow length (1,085 feet), which we call the *threshold length*.

---

[3] Davidson Well #2 is located approximately 1.8 miles north of the Montgomery and Associates 5-foot drawdown contour (in Montgomery and Associates Inc. 2010). That modeling effort showed a 0.31 foot drawdown at 150 years in Reach 2, and 0.98 feet at 1,000 years.

[4] Coefficient of variation (CV) is the standard deviation divided by the mean. For this study, CV provides a good method of comparison among years, because the mean flow length has changed considerably over time. Therefore, comparing standard deviations is not as informative.

We then developed a multiple regression model to determine the relationship between the number of flow segments that met or exceeded this threshold and other factors thought to influence flow segments including length of flow, year, month, and month*year interaction[5].

Testing accuracy of groundwater-surface water relationship. We used 2008 and 2011 LiDAR to evaluate the accuracy of the groundwater-surface water relationship at the Davidson Well #2 and compared these data to figures and language in Tetra Tech (2010a) to determine if the Tetra Tech analysis was correct. A review of the LiDAR data collection can be found in Swetnam and Powell (2010).

Results and Discussion

Cienega Creek: Baseflow. From 2001-2014 average annual baseflow was 0.73 ft^3/sec but this varied considerably by month: March = 1.12 ft^3/sec, June = 0.32 ft^3/sec, September = 0.91 ft^3/sec, and December = 0.65 ft^3/sec. Baseflow declined as depth to groundwater increased, as explained by a linear function ($F_{1,56}$= 157.2, $P < 0.001$, $R^2 = 0.74$) (Figure 1). All four sampling

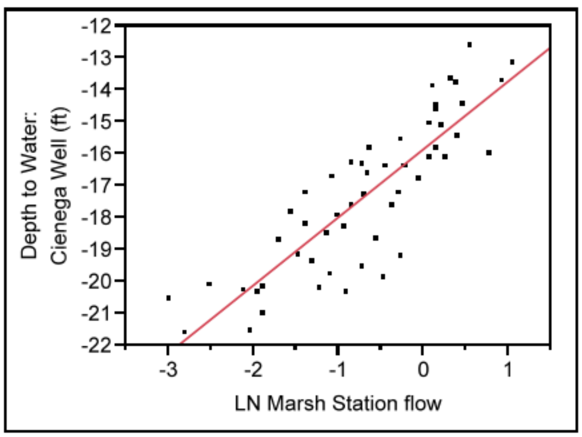


Figure 1. Relationship between flow (log [LN] of cubic feet/second) and depth to water at the Cienega Well. The linear model (red line) explains 74% of the variation in the data. Model used all data from June 2001-June 20014.

[5] In regression analysis (and for this situation), *interaction* occurs when a relation between two variables is modified by another variable. In other words, the strength or the sign (i.e., direction) of a relation between two variables is different depending on the value of some other variable.

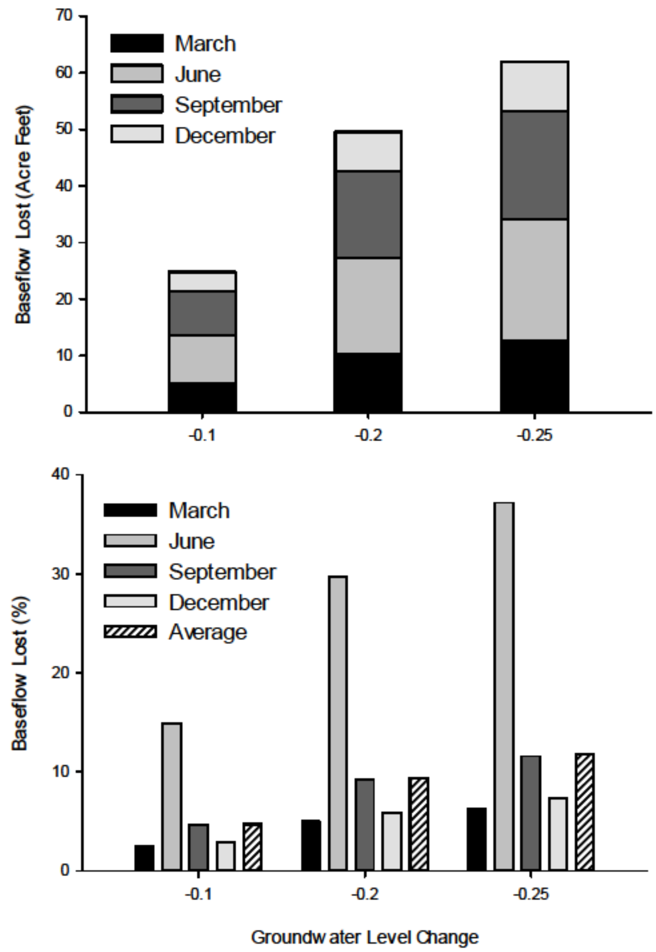


Figure 2. Modeled loss of streamflow volume (acre feet [top] and percent [bottom]) as a function of changes in groundwater level, by season. While total flow loss for the June period is similar to that of September, for example (top graph), this greater percentage of baseflow lost results from the lower baseflow volume during June.

periods (March, June, September, and December) showed a similar relationship ($P<0.004$), with the strength of the model fit (as expressed by R^2) ranging from 0.54 for December to 0.81 for March. Using the regression equations, we were able to calculate that with a 0.1 feet decline in groundwater elevation would lead to an average annual loss of 25 acre feet of water (Figure 2). Annual losses increase to 63 acre feet with 0.25 feet reduction in groundwater level at the Cienega Well.

Perhaps more important than total volume of water lost is the percentage of baseflow predicted to be lost. Average annual estimates of baseflow reduction range from 4.7% with a 0.1 feet reduction of groundwater level to 11.8% reduction with a 0.25 feet reduction (Figure 2)

As reported earlier, baseflow varied among months and this made inter-month percent loss in baseflow quite different than total loss. June is especially important to notice; it showed an estimated 14.9% loss of baseflow at Marsh Station with a 0.1 feet decline in the aquifer to as high as 37% with a 0.25 feet decline in the aquifer (Figure 2).

Cienega Creek: Streamflow length. Streamflow length and depth to water was explained by a linear function ($F_{1,12}$= 67.2, $P < 0.001$, $R^2 = 0.84$)[6] (Figure 3). Using this model, we would expect that a groundwater drawdown of 0.1 foot would result in a loss of 434 linear feet of Cienega Creek (Table 1). Because of uncertainty about the models and the high value of Cienega Creek, we also modeled drawdown of 0.25 feet, which results in a reduction of streamflow length of 1,085 feet. The mean extent of streamflow within the CCNP from 2000-2013 has been approximately 12,500 feet. A reduction of 434 feet would reduce surface water extent by 3.4% and 1,085 feet would be equal to approximately 8.6% reduction is flow extent.

It is important to note that the Cienega Well was used in the report by Westland (2012; page 5), but they claim that their model of depth to water and quarterly flow length showed an unusual statistical distribution and therefore use of that well was discounted in favor of data from the Jungle well. The June length of flow data in relation to the Cienega Well do not show this issue (Figure 4) and the Cienega Well is certainly useful for estimating loss of streamflow length.

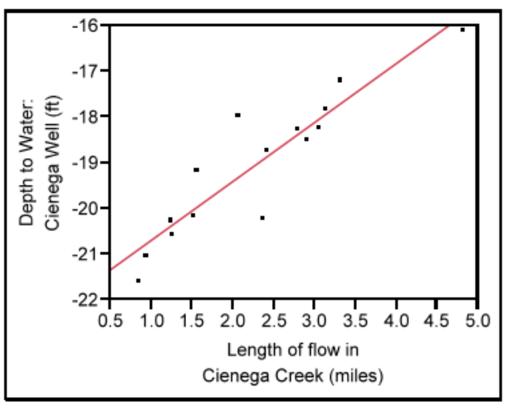


Figure 3. Relationship between length of flow of Cienega Creek at the Cienega Creek Natural Preserve and depth to water at the Cienega Well. The linear model (red line) explains 84% of the variation in the data.

---

[6] It is important to note that we also modeled the relationship using a 2nd and 3rd order polynomial, which improved results somewhat, particularly for the 3rd order polynomial (R^2 = 0.87). However, for simplicity, we use the following formula to model the impact in groundwater drawdown on Cienega Creek within the CCNP: Length of flow (miles) = 14.662 + 0.650*depth of water at the Cienega Well (feet).

Table 1. Modeled reduction in streamflow length of Cienega Creek at the Cienega Creek Natural Preserve. Percent reduction is based on the mean June streamflow length of 2.38 miles (12,566 feet).

Draw-down (feet)	Arbitrary starting well depth (feet)	Streamflow length		Feet lost due to draw-down	Percent reduction in streamflow length
		Miles	Feet		
0	-18	3.10	16,347	0	0.0
-0.1	-18.1	3.01	15,913	-434	-3.4
-0.2	-18.2	2.93	15,479	-868	-6.9
-0.25	-18.25	2.90	15,262	-1085	-8.6

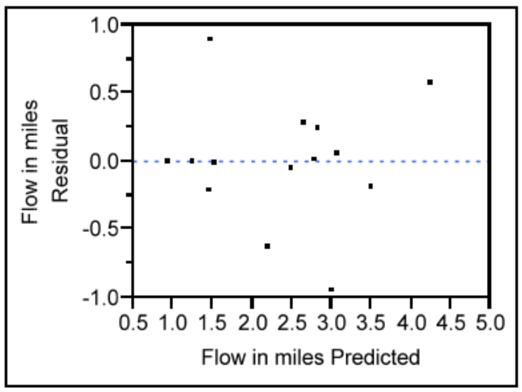


Figure 4. The dispersion of residuals from the model of streamflow length in Cienega Creek to depth to water in Cienega Well (June; Figure 1) shows that a linear model for this relationship is a valid statistical approach. Westland (2012), using data from all intra-annual streamflow lengths measurements, argued that this was not a statistically valid relationship. (Myers [2014] had similar issues with data from Empire Gulch). However, by using June data only, a linear model is appropriate.

It is critical to note that the results between the modeling results by Westland (2012) and those reported here are significantly different. Using data from the Jungle Well, Westland (2012) found that with a 0.1 foot decline in depth to water there would be 176 foot reduction in flow length; just 41% of our results. They also did not model a scenario that may result from a mine impact that is greater than other projections but may be within the realm of possibility (i.e., a 0.25 foot reduction in depth to water).

<u>Davidson Canyon: Groundwater and Baseflow Extent</u>. Streamflow length and depth to water was explained by a linear function ($F_{1,26}$= 89.9, $P < 0.001$, $R^2 = 0.78$) (Figure 5), which we used to model the impact in groundwater drawdown on Davidson Canyon: Length of flow (miles) = 2.180 + 0.085*depth of water at the Davidson #2 Well (feet) (Figure 5).

Using this model, we would expect that a groundwater drawdown of 0.1 foot would result in a loss of 45 linear feet of Davidson Canyon and a drawdown of 0.25 feet resulted in a reduction of streamflow length of streamflow of over 112 feet (Table 2). Percent reductions are very similar to that of Cienega Creek and ranged from 3.0% to 7.6%. Using the 150 and 1,000 year estimates of impacts on groundwater (0.31 feet and 0.98 feet, respectively; Montgomery and Associates, 2010) would result in 9.4% and 30% loss of surface flow in Davidson Canyon, respectively. For comparison, the groundwater model by Montgomery and Associates (2010) equates the 0.98 feet of drawdown with a 0.29 miles (1,530 feet) reduction in stream length based on the drying of several of the 800 x 800 foot model grid cells where leakage to the aquifer exceeds streamflow into the reach.

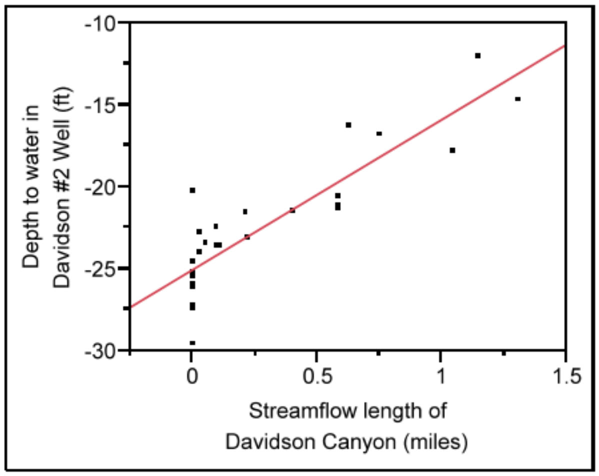


Figure 5. Relationship between length of flow of Davidson Canyon at the Cienega Creek Natural Preserve and depth to water at the Davidson #2 Well. The linear model (red line) explains 77% of the variation in the data. This model does not take into consideration changes in surface water runoff from the mine site.

Table 2. Modeled reduction in streamflow length for Davidson Canyon. Percent reduction is based on the mean June streamflow length of 0.28 miles (1,478 feet).

Draw-down	Arbitrary starting well depth in feet	Streamflow length Miles	Streamflow length Feet	Feet of streamflow lost due to draw-down	Percent reduction in streamflow length
0	-20	0.4885	2,579	0	0.0
-0.1	-20.1	0.4800	2,534	-45	-3.0
-0.2	-20.2	0.4716	2,490	-89	-6.0
-0.25	-20.25	0.4673	2,467	-112	-7.6
-0.31	-20.31	0.4622	2,441	-138	-9.4
-0.98	-20.98	0.4071	2,141	-438	-30.0

Unlike in Cienega Creek, the groundwater model results used here to calculate drawdown are taken from locations within or very near the 5-foot drawdown contour and are assumed to be more reasonably certain than model results for Lower Cienega Creek. Accordingly, the stream length losses associated with nearly a foot of drawdown must be taken into consideration when evaluating the Rosemont mine's impact on lower Davidson Canyon. The stream length losses (0.29 miles; 1,530 feet) predicted by Montgomery and Associates (2010) are larger than those predicted in this study using the well depth to stream length regression analysis (Table 2). Taken together however, they provide a range of possible outcomes resulting from increased depths to groundwater due to the Rosemont mine.

Tetra Tech (2010a) suggests that this reach of Davidson Canyon is not connected to the regional groundwater system, and that streamflow impacts due to drawdown of the regional aquifer therefore are unlikely to occur. Yet the results of our analysis (Figure 5) provide very convincing evidence that contradicts this position.

We also take issue with Tetra Tech (2010a) data. Underpinning Tetra Tech's assertion is an illustration and a channel bed measurement at the Davidson Canyon stream gage (Figure 6). The accuracy of this figure relies on a "mid-channel bed" measurement taken by Tetra Tech (2010a). We examined Pima County LiDAR-generated elevation data at the same location and found that Tetra Tech's "mid-channel" bed elevation is five feet higher than the channel bed in 2008. We then examined 2011 LiDAR bed-elevations at the same location, which rule out the possibility that five feet of aggradation occurred, as would be required by Tetra Tech channel bed measurement. Instead, the actual bed elevations in 2008 and 2011 vary by less than 0.6 feet (Figure 7). Thus, the actual channel-bed is within a foot or two of the water table as measured in Davidson #2 Well.

The water-level measurements presented by Tetra Tech came from the Outstanding Waters nomination submitted by Pima Association of Governments (2005), which identified this reach as intermittent. Tetra Tech (2010a) uses the same data to infer than this portion of the channel is ephemeral. It is unreasonable to assume that groundwater never could discharge to the surface, or that it has been persistently below the bed between 1994 and 2004, as is indicated by Tetra Tech with the horizontal line connecting the last two groundwater measurements (Figure 6). It is even more unreasonable to extend that inference to the entire upstream reach, as is done by Tetra Tech (2010a).

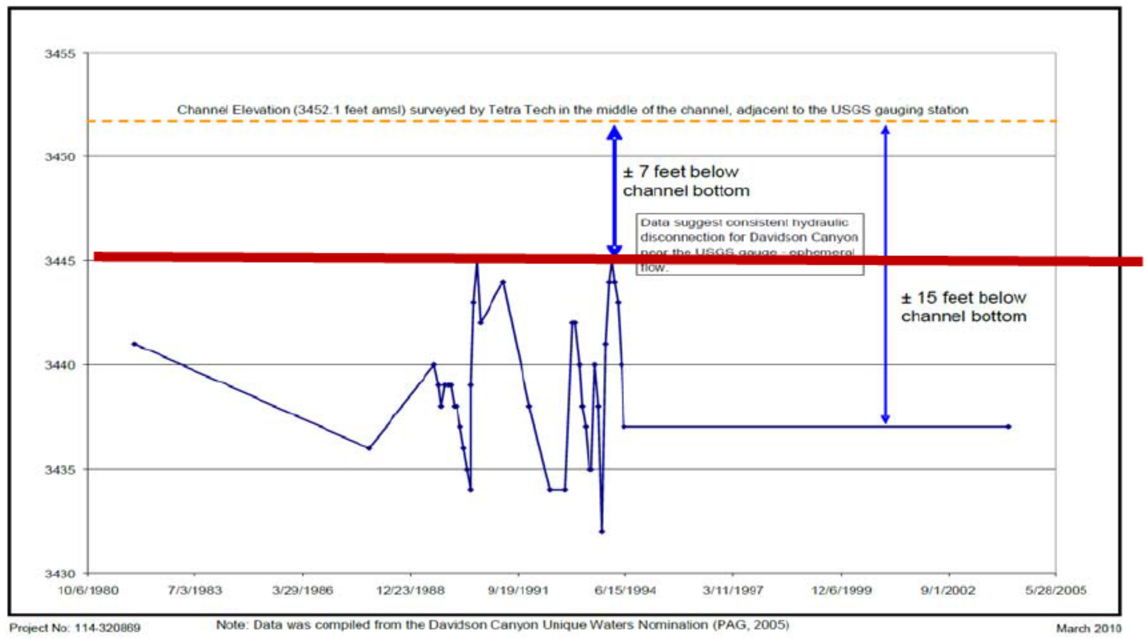


Figure 6. Tetra Tech's (2010a) Figure 5, amended to show actual channel bed elevation at the location. Red line shows position of the 2008 and 2011 channel bed based on LiDAR data.

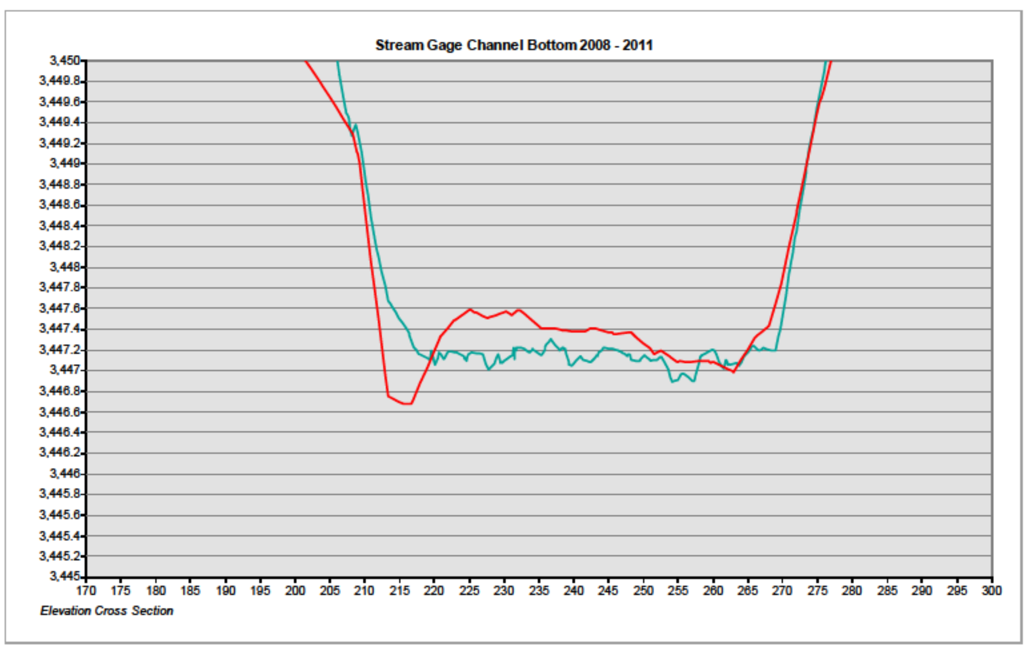


Figure 7. LiDAR channel cross-sections, 2008 in red, 2011 in green. Bed elevation varies by less than 0.6 feet.

Additionally, the work of Montgomery and Associates (2010) supports a connection to the regional aquifer in lower Davidson Canyon. The pre-mining steady state model simulated the interaction between the regional aquifer and the stream. The model produced results for both discharge and streamflow length that approximately matches past observations of flows and the extent of the Davidson perennial reach. If the regional aquifer was disconnected from the perennial reach, or so far below it that it does not impact surface flows, then one would expect that to be reflected in the model simulation showing a dry reach. It does not. Further evidence supporting a connection to the regional aquifer comes from interpretation of isotopic data by Dr. Chris Eastoe (Letter from County Administrator's Office to Robert Scalamera, Project Manager, Arizona Department of Environmental Quality (ADEQ); letter dated April 4, 2014).

These various lines of evidence, combined with errors and omissions by Tetra Tech, undermines Tetra Tech's argument that the intermittent baseflows in Davidson are unrelated to the regional aquifer. Combined, these analyses suggest that the impacts of Rosemont mine on Davidson Canyon and the Outstanding Arizona Waters have been understated in both the final environmental impact statement (U.S. Forest Service 2013), the draft water quality certification by ADEQ (Arizona Department of Environmental Quality 2014), and the biological opinion (U. S. Fish and Wildlife Service 2013). Based on this new information, the impact to the Davidson Canyon Outstanding Arizona Waters reach by the Rosemont project should be revaluated regarding the potential take of endangered species and the impact to riparian and water resources.

<u>Davidson Canyon: Effect on Runoff</u>. Key to understanding the mine's full impact on water resources requires a better understanding of the surface water runoff changes in the Barrel and Davidson canyons. Pima County has repeatedly objected to the methodology and the findings from Rosemont and their consultants as well as data that have been incorporated into the final environmental impact statement and biological opinion including that:

- Potential runoff reduction impacts on downstream riparian and water resources for all phases of the mine life are not fully disclosed.
- Cumulative runoff reduction impacts on downstream riparian and water resources, Davidson Canyon and Cienega Creek, are not fully disclosed.
- Deficiencies in the analysis of downstream water volume effects on Davidson Canyon, Cienega Creek and Outstanding Arizona Waters have resulted in the underestimation of reduction in surface water flows in FEIS.
- The hydrological analysis supporting the surface water evaluation is inadequate, as the modeling should have considered shorter duration, high-intensity rainfall events' and the FEIS misrepresents the methods followed as those prescribed by Pima County.
- Rosemont Copper still intends to capture and retain surface water from watersheds northeast of the tailings, west of the mine pit, and south of the waste rock disposal

area. Instead, this water should be released downstream to mitigate reductions in stream flows and impacts to riparian vegetation.

To inform the decision regarding the impact to riparian resources and potential take of endangered species, these runoff-related objections need to be addressed. In addition to the above mentioned objections, the Biological Opinion cites work by SWCA (2012) that has not been made available for Pima County's review, either as a Cooperator or as a participant in the Hydrology Work Group recently convened by the Federal agencies. The SWCA work apparently extrapolates runoff volume reductions in Barrel Canyon and Davidson Canyon above the Highway 83 bridge to the Outstanding Arizona Water reach downstream.

Acceptable methods for determining flood routing are described in Pima County Regional Flood Control District Technical Policy 18. In this document, the methods entitled "*Acceptable Model Parameterization for Determining Peak Discharges"* should be employed to determine the reduction in streamflow in Lower Davidson Canyon and Cienega Creek as a result of changes in the upper watershed due to the Rosemont project. Myers (2014) provides an additional critique of Westland's (2012) methodology to evaluate impacts of surface water impoundments on Davidson Canyon and highlights that the methods used are deficient to provide an understanding of the impacts.

Rosemont and their consultants have reported that reductions in the volume of channel infiltration in the headwaters, reductions in total annual runoff volume, and reductions in peak flood magnitude all will have minimal effects on the OAW reach (WestLand Resources Inc. 2011, Zeller 2011, SWCA Enivironmental Consultants 2012). Combined with previously discussed Tetra Tech (2012a, 2012b) interpretations, these arguments would suggest that:

- When groundwater is considered, surface water is the most important factor in supporting lower Davidson Canyon.
- When mine impacts that effect surface water are considered, lower Davidson is too distant from the headwaters to be impacted.
- When shallow groundwater and channel subflow from precipitation recharge in the headwaters are considered, the OAW reach is not connected to the upper watershed due to bedrock constrictions in the shallow aquifer.

These arguments, when summed up, suggest that the OAW reach of Davidson Canyon is isolated from its watershed entirely and apparently without a water source. In short, these studies reveal a disturbing pattern of minimizing impacts from the Rosemont mine on all aspects of the hydrologic cycle.

Fragmentation of Flow in Cienega Creek. As has been reported elsewhere (WestLand Resources Inc. 2012, Powell 2013), streamflow length of Cienega Creek has declined precipitously since the 1980's and 1990's (Figure 8). In part because of this decline, streamflow length became highly variable as the streamflow responded to a shallow aquifer that was declining because drought and groundwater pumping. Looking more closely at the streamflow length data, not only was the streamflow length declining, but the streamflow segments were becoming more fragmented. This variability can be seen a number of ways, including the coefficient of variation (Figure 9) and number of segments per year (Figure 10).

From June 2001 to September 2012, there were a total of 341 recorded stream segments, 161 of which (47%) were at or below the threshold length established for this analysis (i.e., 1,085 feet). The number of stream segments below the threshold length was most influenced by length of flow in Cienega Creek (multiple regression, $F_{4,40} = 5.4$, $P = 0.0015$, $R^2 = 0.35$; Table 3) and not by any other factor (Table 3).

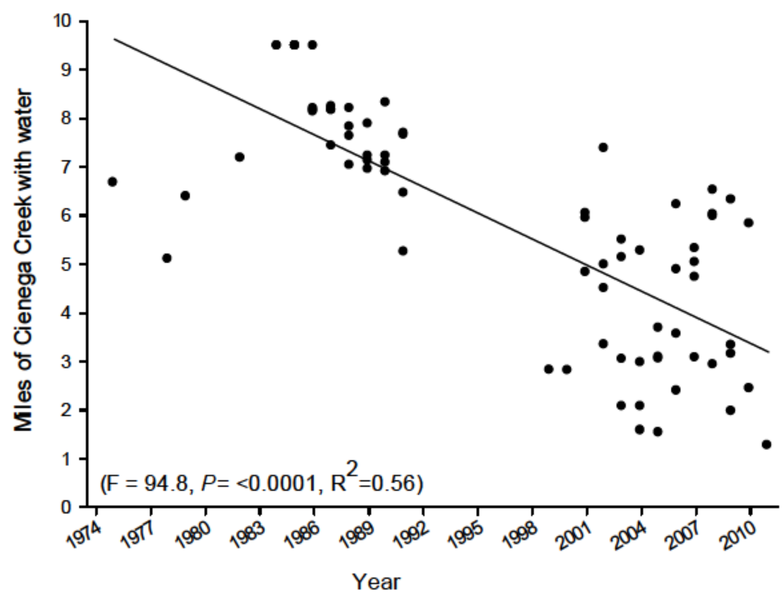


Figure 8. Extent of stream flow at Cienega Creek Natural Preserve (from Powell 2013) has both declined (solid line shows linear regression model) and shown more intra-annual variability. Maximum flow extent is 9.5 miles.

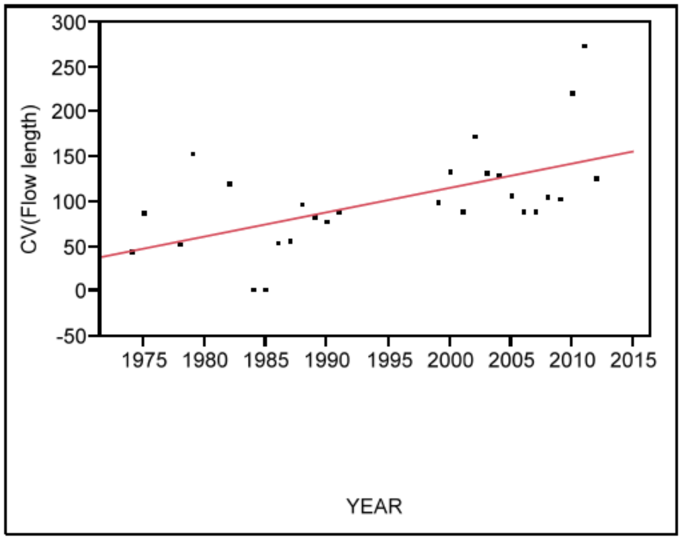


Figure 9. An increase in the coefficient of variation of streamflow length demonstrates that streamflow length is becoming increasingly variable over time. Increased variability can lead to instability of the system.

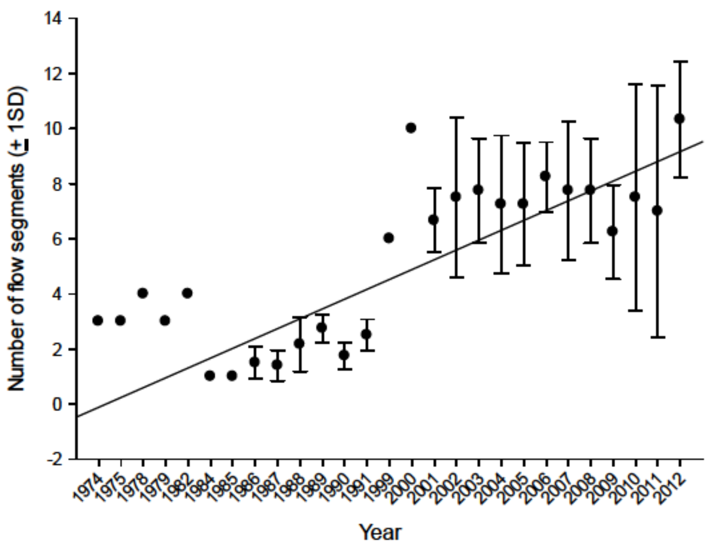


Figure 10. The number of streamflow segments has increased over time. As with flow length, increased variability can lead to isolation and loss of organisms that rely on open water, including Gila chub, Gila topminnow, and Huachuca water umbel. Analysis of variance test (solid line) shows this relationship to be significant ($F_{1,25}$= 11.8, P = 0.002, R^2 = 0.32).

Table 3. Results of multiple regression analysis on the relationship between number of flow segments that met the threshold (≤1,085 feet) and other variables thought to influence the number of segments.

Effect	Estimate	F	P
Length of flow in Cienega Creek	51.1	19.5	<0.0001
Year	0.2	0.1	0.804
Month	6.0	1.6	0.217
Year*Month interaction	0.3	0.1	0.781

Discussion: Impacts on Species

Habitats of aquatic and mesic-riparian species in Cienega Creek and Davidson Canyon are decreasing in size and quality as the result of the reduction in the amount of available groundwater and surfacewater. This section highlights the likely impact on individual species, but looking broadly at the impacts of loss, fragmentation, and isolation that could result from threats to shallow groundwater and stormwater is instructive.

Cienega Creek is currently under stress. Water, the lifeblood of the system, is declining by every measure. There is a large and growing body of literature on the causes and consequences of ecosystems under stress (e.g., Odum 1985, Rapport et al. 1998, Rapport and Whitford 1999, Scheffer et al. 2001, Folke et al. 2004) and key among these findings is that as threats increase, habitat extent and quality declines, variability increases, and a system is more susceptible to threats that would not otherwise have impacted the system, such as loss of native species, increase in invasive species, etc. In essence, the system becomes less resilient.

Of course, the current state of Cienega Creek has nothing to do with the Rosemont mine. Yet it should be clear from the data presented here that any future impacts to the surface and groundwater resources of the system could have a far greater impact than indicated by either Rosemont or the permitting agencies. Another way to look at the impacts of the Rosemont mine is to say that if it was already built and impacting groundwater during the current drought, then Cienega Creek could lose as much as 37% of the baseflow during the critical pre-monsoon season, potentially leading to severe population declines of T&E species.

Gila topminnow. The habitat of Gila topminnow can be a broad range of water types such as pools and riffles and seem to prefer stream margins. Preferred habitats contain dense mats of algae and debris, usually along stream margins or below riffles, with sandy substrates sometimes covered with organic mud and debris. The largest natural populations of Gila topminnow occur in Cienega Creek (Bodner et al. 2007). Gila topminnow have recently been monitored at the CCNP (Marsh et al. 2009, 2010)[7] and in some areas are found in stream reaches that often classify as intermittent based on PAG wet-dry data, as well as perennial reaches. The aquatic habitats in the CCNP are a patchwork of disconnected habitat patches that are only connected during high-volume stormflows.

The modeled decline of habitat highlighted in this report, which includes reduction in the amount of baseflow and surface water extent (Figures 1-3, Table 1) and increase fragmentation (Table 3) will impact this species, especially during this critical June period. For the topminnow, which can live in very shallow water, further fragmentation and loss of key refugia could have significant impacts. This is acknowledged by the U.S. Fish and Wildlife Service in the Biological Opinion (U. S. Fish and Wildlife Service 2013; page 287), but their analysis is qualitative in nature. The results presented here can help a more robust analysis.

Gila Chub. Gila chub have an affinity for deeper pools (as compared to Gila topminnow) in slow velocity water and are often associated with cover such as undercut banks, root wads, and instream debris piles. At the CCNP, their distribution is largely restricted to three pools, one of which is found in an intermittent reach (Figure 11). The drawdown of the aquifer that supports critical base flows for this species will likely reduce the size and volume of the pools in which the Gila chub live.

The data in this report (e.g., Figures 1-3, Table 1) should cause a reevaluation of the impacts of groundwater decline for this species. For the Gila chub, the U.S. Fish and Wildlife Service (2013, page 267) use the analysis by Westland Resources Inc. (2012) as a basis for determination of impact. As we have noted, that report underestimated impacts to stream reaches. Our report points to a need to recognize that if drawdowns eliminate the shorter, persistent reaches, then recolonization of intermittent aquatic habitats when joined by flooding will depend on fewer, more widely spaced perennial refugia. Also, as drawdown occurs, occupied Gila chub pools will reduce in surface water depth, thereby leading to a possibility of increased water temperatures. This could be a problem for this species (and not for Gila topminnow) because of their lower tolerance of high water temperatures (Carveth et al. 2006).

---

[7] These studies have noted numbers of Gila chub caught at the CCNP but the survey methods were not designed to estimate populations or even catch-per-unit effort. The Biological Opinion (U. S. Fish and Wildlife Service 2013) does not take this into account (page 254; though it states later [page 273] that the methods were not meant to enumerate trends). Though restricted to a few pools at CCNP, there are many more individuals than are reported by these monitoring efforts.

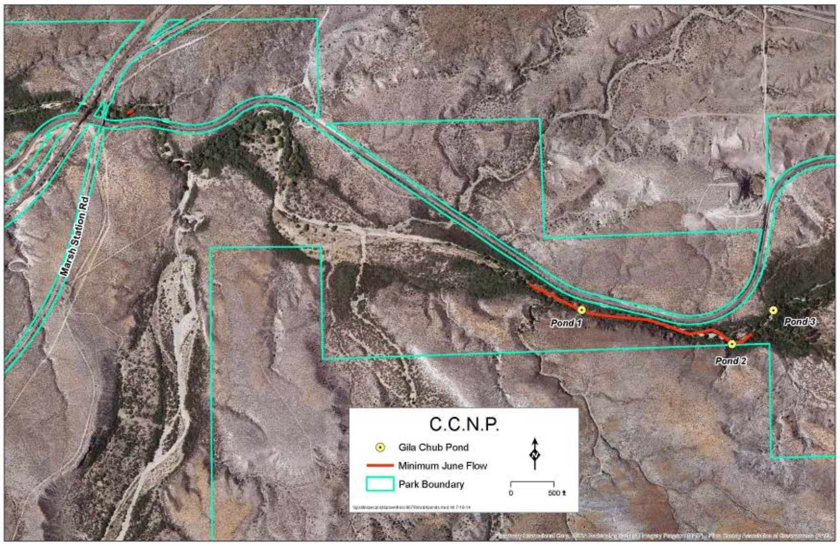


Figure 11. Location of pools with Chub in relation to areas that have a minimum June flow. Pool 3 is located in an intermittent stretch of the Creek, but that pool is very dynamic, as are the presence of chub. Pool 1 and Pool 2 contain chub more consistently. Figure by Mike List (Pima County IT).

Figure 12. This adult northern Mexican gartersnake was found feeding on lowland leopard frog tadpoles at the Cienega Creek Natural Preserve on June 13, 2014. Predicted surface water declines because of the mine would impact the extent of habitat and the species' primary food sources: fish and tadpoles. Photograph by Julia Fonseca.

Northern Mexican Gartersnake. This species is highly aquatic and only ventures a short distance away from water for hibernation and occasionally for foraging (U.S. Fish and Wildlife Service 2014). Its diet primarily consists of small fish and frogs, which are found on the CCNP. Though observations of this species at the Preserve are very rare, they have been found there (Rosen and Schwalbe 1988, Rosen and Caldwell 2004), including as recently as June 13, 2014 when one adult was confirmed (Figure 12). An additional juvenile may also have been found, but no positive identification was made. The historical decline in the amount and extent of surface water (Figure 8) and the modeled decline in these resources as a result of the mine (Figures, 1-3, Tables 1, 2) will impact the extent of habitat and the aquatic prey base upon which these species depend. The northern Mexican gartersnake was not a part of the consultation for the biological opinion for the mine (U. S. Fish and Wildlife Service 2013), but will be part of the reinitiated consultation process (letter from USFWS Field Supervisor Steve Spangle to Forest Service Supervisor Jim Upchurch, dated May 16, 2014). The presence of the species and the modeled impacts should be considered as part of those deliberations.

Yellow-billed cuckoo. The yellow-billed cuckoo prefers large willow and cottonwood trees for nesting and foraging. The status of the population at the Cienega Creek NP is not entirely certain, but a single-pass survey by Powell (*unpublished data*) in 2013 revealed at least 11 individuals. Based on the work by Corman and Magill (2000), we know that the yellow-billed cuckoos populations at the CCNP and on the Las Cienegas NCA are some of the largest among small creeks in Arizona. Unfortunately, the slow desiccation of some areas of the CCNP in the last years has significantly impacted the gallery riparian forest on which the cuckoo depends for nesting, even as other forest patches continue to gain canopy volume and height (Figure 12, Swetnam et al 2013).

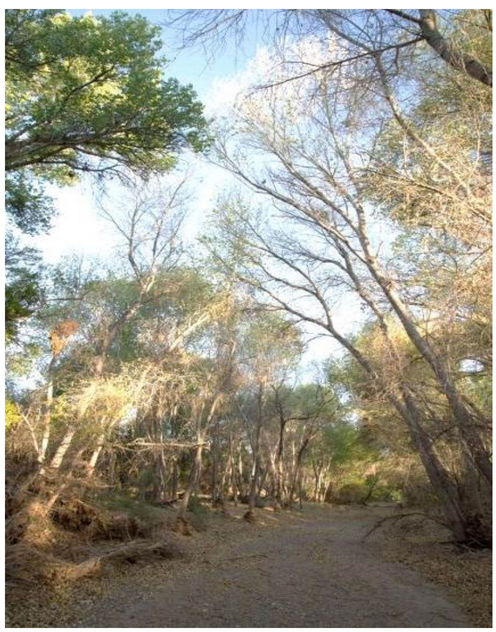


Figure 12. Photo from Cienega Creek NP showing impacts of the current drought on the thinning canopy of cottonwood trees, the primary tree used for nesting and foraging by the yellow-billed cuckoo. Loss of groundwater from the Rosemont mine will exacerbate this problem. Photo taken on May 30, 2014 very close to where yellow-billed cuckoos were detected in 2013. Cuckoos would be unlikely to nest in an area with such an open canopy.

There has been a considerable amount of research on cottonwood and willow trees as it relates to depth to water and tree species composition in the desert southwest (e.g., Stromberg et al. 1996, Horton et al. 2001, Harner and Stanford 2003, Stromberg et al. 2007, Hidalgo et al. 2009, Merritt and Poff 2010). The work by Lite and Stromberg (2005) and Leenhouts et al. (2006) is particularly relevant to the situation at CCNP. Studying the threshold between groundwater depth and flow permanence on the presence and vigor of cottonwood trees, Lite and Stromberg (2005) found that flow permanence was the single greatest hydrologic predictor for the presence of cottonwood trees. Flow permanence of 76% was viewed as important, as was depth to water of approximately 3m, a result that that has been found by other studies (Horton et al. 2001). Lite and Stromberg (2005) believe that flow permanence is probably a surrogate for other (not studied) hydrological characteristics, but it provide a good starting place for thinking about how changes in groundwater drawdowns will impact the habitat of yellow-billed cuckoos. Flow permanence is a particularly helpful measure because it is easily observed, as opposed to depth to water, which can be measured at various wells but varies spatially. Pima County is currently pursuing an analysis of surface water extent and vegetation change over time. We hope to have results in the coming weeks.

Huachuca water umbel. The Huachuca water umbel requires permanent water and grows on the margins of streams. First detected in 2001 within patches of cattail and bulrush (Engineering and Environmental Consultants Inc. 2001), the umbel appeared to have colonized a location in the CCNP from larger populations upstream. The cattail-bulrush wetland in which umbel colonized was considered a perennial reach in 2000-2001, but subsequently desiccated because of the headcut, which was studied intensively by the Pima Association of Governments (PAG; 2009b). The PAG study included piezometers which documented the loss of near-surface waters and dewatering of sediment during pre-monsoonal droughts that precede headcutting during subsequent floods. The dewatering of sediment during pre-monsoonal months likely rendered umbel habitat unsuitable, even if no headcutting occurred.

The umbel has not been seen in the CCNP for a number of years, in spite of casual searches during quarterly walk-throughs, and a dedicated search during 2013. Colonization events may be infrequent, and with reductions in areas of permanent water from the impacts of the Rosemont mine, there will be less available habitat for natural establishment and persistence.

Conclusions

To our knowledge, this is the first attempt to use water resource data collected at the CCNP and Davidson Canyon to better understand the range of potential impacts that the mine might have on water resources and the T&E species that rely on this resource. Our analysis show:

- The statistical relationship between depth to water and baseflow and streamflow extent is outstanding for the paired relationships of Cienega Creek and Cienega Well (Figure 1) and Davidson Canyon and Davidson Canyon #2 well (Figure 3);
- These data, along with a critique of Rosemont-sponsored data collection efforts that relied on faulty data and assumptions, provide the strongest support to date for the connection between surface water and groundwater resources in Davidson Canyon and Cienega Creek.
- Using models that express this relationship, we show that previous modeling efforts (WestLand Resources Inc. 2012) significant underestimated the loss of streamflow length that could result from the mine. We also estimate, for the first time, the amount and percentage of baseflow that will be lost with a drawdown of the aquifer the supports the aquatic and riparian resources of lower Cienega Creek and Davidson Canyon.
- Groundwater drawdowns of the magnitude predicted and within possibility show that there will be significant and measurable impacts on the extent of surface water and habitat for the Gila topminnow and Gila chub (Table 1) and other species (Tables 1 and 2). This is particularly critical during June when the creek is at its lowest baseflow and extent;
- Fragmentation of aquatic habitat shows and inverse relationship to flow extent (Table 3); that is, as extent declines, fragmentation will increase. This will lead to additional take and threat to T&E species that has not been previously considered;
- There is still considerable uncertainty about the impacts of surface water diversions into Cienega Creek and Davidson Canyon. Developing a better understanding of these impacts will allow a more refined accounting of impact on the aquatic system of Cienega Creek and Davidson Canyon and the species that call these places home.

Literature Cited

Arizona Department of Environmental Quality. 2014. Clean Water Act Section 401 Water Quality Certification, U.S. Army Corps of Engineers Public Notice / Application No.: SPL-2008-00816-MB ADEQ LTF 55425. Phoenix, Arizona.

Bodner, G., J. Simms, and D. Gori. 2007. State of the Las Cienegas National Conservation Area: Gila topminnow population status and trends 1989-2005. The Nature Conservancy, Tucson, Arizona.

Carveth, C. J., A. M. Widmer, and S. A. Bonar. 2006. Comparison of upper thermal tolerances of native and nonnative fish species in Arizona. Transactions of the American Fisheries Society 135:1433-1440.

Corman, T. E. and R. T. Magill. 2000. Western yellow-billed cuckoo in Arizona: 1998 and 1999 survey report to the Nongame and Endangered Wildlife Program, Arizona Game and Fish Department. Technical Report 150, Phoenix, Arizona.

Engineering and Environmental Consultants Inc. 2001. Final report: Huachuca water umbel surveys of Cienega Creek Preserve, Bingham Cienega Preserve, and La Cebadilla Property, Pima County, Arizona. Report to the Pima County Regional Flood Control District.

Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C. S. Holling. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. Annual Review of Ecology Evolution and Systematics 35:557-581.

Harner, M. J. and J. A. Stanford. 2003. Differences in cottonwood growth between a losing and a gaining reach of an alluvial floodplain. Ecology 84:1453-1458.

Hidalgo, H. G., T. Das, M. D. Dettinger, D. R. Cayan, D. W. Pierce, T. P. Barnett, G. Bala, A. Mirin, A. W. Wood, C. Bonfils, B. D. Santer, and T. Nozawa. 2009. Detection and attribution of streamflow timing changes to climate change in the western United States. Journal of Climate 22:3838-3855.

Horton, J. L., T. E. Kolb, and S. C. Hart. 2001. Responses of riparian trees to interannual variation in ground water depth in a semi-arid river basin. Plant Cell and Environment 24:293-304.

Leenhouts, J. M., J. C. Stromberg, and R. L. Scott, (eds.). 2006. Hydrologic requirements of and consumptive ground-water use by riparian vegetation along the San Pedro River, Arizona. U.S. Geological Survey Scientific Investigations Report 2005-5163, Reston, VA.

Lite, S. J. and J. C. Stromberg. 2005. Surface water and ground-water thresholds for maintaining *Populus-Salix* forests, San Pedro River, Arizona. Biological Conservation 125:153-167.

Marsh, P. C., B. R. Kesner, J. A. Stefferud, and S. E. Stefferud. 2009. Fish monitoring of selected streams of the Gila River Basin, 2008. Unpublished report to the Bureau of Reclamation, Phoenix Area Office, Phoenix, Arizona.

Marsh, P. C., B. R. Kesner, J. A. Stefferud, and S. E. Stefferud. 2010. Fish monitoring of selected streams of the Gila River Basin, 2009. Unpublished report to the Bureau of Reclamation, Phoenix Area Office, Phoenix, Arizona.

Merritt, D. M. and N. L. Poff. 2010. Shifting dominance of riparian *Populus* and *Tamarix* along gradients of flow alteration in western North American rivers. Ecological Applications 20:135-152.

Montgomery and Associates Inc. 2010. Revised report: Groundwater flow modeling conducted for simulation of proposed Rosemont pit dewatering and post-closure, Vol. 1: Text and tables. Prepared for Rosemont Copper. Tucson, Arizona.

Myers, T. 2014. Technical memorandum: Review of surface water/Groundwater relations in the Cienega Creek watershed. Memorandum to the Pima County Regional Flood Control District. Dated: June 25, 2014.

Odum, E. P. 1985. Trends expected in stressed ecosystems. Bioscience 35:419-422.

Pima Association of Governments. 2005. Unique Waters nomination for Davidson Canyon. Prepared for the Pima County Regional Flood Control District, Tucson, Arizona.

Pima Association of Governments. 2009a. Cienega Creek Natural Preserve surface water and groundwater monitoring. Annual report for the 2007-2008 fiscal year. Unpublished report to the Pima County Regional Flood Control District, Tucson, Arizona.

Pima Association of Governments. 2009b. Evaluation of riparian habitat and headcutting along Lower Cienega Creek. Unpublished report to the Arizona Water Protection Fund.

Pima Association of Governments. 2011. Surface water and groundwater monitoring project- PAG annual report, Fiscal year 2009-2011. Unpublished report prepared by the Pima County Regional Flood Control District, Tucson, Arizona.

Pima County. 2012. Comments on the draft Environmental Impact Statement for the Rosemont Mine. Comments provided to Jim Upchurch, Forest Supervisor, Coronado National Forest, Tucson, Arizona.

Pima County. 2013. Pima County comments- Rosemont Copper Mine Preliminary Administrative Final Environmental Impact Statement. Comments provided on August 14, 20013 to Jim Upchurch, Forest Supervisor, Coronado National Forest, Tucson, Arizona.

Powell, B. F. 2013. Trends in surface water and ground water resources at the Cienega Creek Natural Preserve, Pima County, Arizona. Unpublished report of the Pima County Office of Sustainability and Conservation, Tucson, Arizona.

Rapport, D. J. and W. G. Whitford. 1999. How ecosystems respond to stress - Common properties of arid and aquatic systems. Bioscience 49:193-203.

Rapport, D. J., W. G. Whitford, and M. Hilden. 1998. Common patterns of ecosystem breakdown under stress. Environmental Monitoring and Assessment 51:171-178.

Rosen, P. C. and D. J. Caldwell. 2004. Aquatic and riparian herpetofauna of Las Cienegas National Conservation Area, Pima County, Arizona. Unpublished report to Pima County Board of Supervisors for the Sonoran Desert Conservation Plan, Tucson, Arizona.

Rosen, P. C. and C. R. Schwalbe. 1988. Status of the Mexican and narrow-headed garter snakes (*Thamnophis eques megalops* and *Thamnphis rufipunctatus*) in Arizona. Unpublished report from Arizona Game and Fish Department to U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.

Stromberg, J. C., S. J. Lite, R. Marler, C. Paradzick, P. B. Shafroth, D. Shorrock, J. M. White, and M. S. White. 2007. Altered stream-flow regimes and invasive plant species: The *Tamarix* case. Global Ecology and Biogeography 16:381-393.

Stromberg, J. C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: The San Pedro River, Arizona. Ecological Applications 6:113-131.

SWCA Environmental Consultants. 2012. Presentation made to U.S. Fish and Wildlife Service and U.S. Forest Service to convey detailed information regarding the Seeps, Springs, and Riparian Impacts Analysis in the Rosemont EIS, in order to inform the USFWS Section 7 consultation process. November 12, 2012.

Swetnam, T. and B. F. Powell. 2010. Example of the use of LiDAR for monitoring vegetation characteristics: An example from the Cienega Creek Nature Preserve. Unpublished report to the Pima County Office of Conservation Science and Environmental Policy, Tucson, Arizona. Accessed on March 25, 2012 from: http://www.pima.gov/cmo/sdcp/Monitoring/PDF/Supplement_D_Examing_Use_of_LiDAR_For_Monitoring_Vegetation.pdf.

Tetra Tech. 2010a. Davidson Canyon hydrogeologic conceptual model and assessment of spring impacts. Tetra Tech Project No. 114-320869. Prepared for Rosemont Copper. Tucson, Arizona.

Tetra Tech. 2010b. Regional groundwater flow model, Rosemont Copper Project. Tetra Tech Project No. 114-320874. Tucson, Arizona.

U. S. Fish and Wildlife Service. 2013. Final biological and conference opinion for the Rosemont Copper Mine, Pima County, Arizona. Appendix F of the Final environmental impact statement for the Rosemont Copper project: A proposed mining operation, Coronado National Forest, Pima County, Arizona. U.S. Department of Agriculture, Forest Service, Southwestern Region. Document number MB-R3-05-6a.

U.S. Fish and Wildlife Service. 2014. Endangered and threatened wildlife and plants; Threatened status for the northern Mexican gartersnake and narrow-headed gartersnake. Federal Register Vol. 79 No. 130.

U.S. Forest Service. 2013. Final environmental impact statement for the Rosemont Copper project: A proposed mining operation, Coronado National Forest, Pima County, Arizona. U.S. Department of Agriculture, Forest Service, Southwestern Region. Document number MB-R3-05-6a.

WestLand Resources Inc. 2011. Rosemont project: Effects of surface water and groundwater diversion on offsite riparian habitats in Davidson Canyon. Report to the Rosemont Copper Company, Tucson, Arizona.

WestLand Resources Inc. 2012. Rosemont project: Potential effects of the Rosemont project on lower Cienega Creek. Report to the Rosemont Copper Company, Tucson, Arizona.

Zeller, M. E. 2011. Predicted regulatory (100-Yr) hydrology and average-annual runoff downstream of the Rosemont Copper Project. Tucson, Arizona.

From: Blumenfeld, Jared
To: "kimberly.m.colloton@usace.army.mil"
Subject: Rosemont Update
Date: Thursday, October 16, 2014 11:03:00 AM

Dear Kim -

I want to thank you and your staff for ongoing strong coordination on Rosemont, and confirm that we did receive a copy of the 9/26 revised mitigation materials from HudBay. As you may know, my staff have contracted with scientists at UC Berkeley, who specialize in stream channel function and design, to do field work at the Sonoita Creek Ranch at the end of October (Marjorie arranged site access and she and the applicant's consultants will participate). The purpose of this work is to assess the probability that the mitigation actions proposed at Sonoita will perform as the applicant expects.

I understand HudBay had an introductory meeting with you recently and that they are anxious to get feedback on the latest submittal. After we complete the planned fieldwork in November, our contractor will produce a report (in a matter of weeks, and in any case no later than the completion of the current ESA consultation process), which we will provide to you to consider in making your final permit decision. I continue to fully support your interest in moving to a permit decision based on the information presented.

Many thanks again,

Jared